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Report on the continuous monitoring of marine recreational fishing in Catalonia

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This document presents the one-year results of a continuous monitoring study on marine recreational fishing in Catalonia during 2021-2022. It was produced by the Catalan Institute of Research for Ocean Governance (ICATMAR), which is a cooperation organism between the Directorate General of Climate Action, Food and Rural Agenda of the Government of Catalonia and the Institute of Marine Sciences (ICM) of Spanish National Research Council (CSIC).

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The working group involved in this report included:

Scientific coordination: Marta Pujol Baucells, Joan B. Company, Laura Recasens, Antoni Lombarte

Scientific – technical working group: Marta Carreton, Joan B. Company, Nuria Marco, Llibori Martinez, Ognen Poposki, Marta Pujol Baucells, Ariadna Purroy, Oriol Ribalta, Joan Ramon Vidal, Joan Yilla

Text revision: Ferran Bustos, Eve Galimany

Layout: Marta Carreton, Marta Blanco

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1
Introduction

Marine recreational fishing (MRF) is a non-professional activity practised for leisure and/or sport by approximately 350 million people globally (Arostegui et al., 2021). Despite being one of the most popular coastal leisure activities worldwide, there is a historical lack of knowledge about its impacts (McPhee et al., 2002), as well as a general lack of data collection, sampling and assessment systems for the activity (Cooke and Cowx, 2005; Hyder et al., 2018; Brownscombe et al., 2019). The increase in the scientific literature focusing on MRF evidences that there is growing interest in the activity and that its importance is increasingly recognised (Rocklin et al., 2014). This trend is understandable considering that it is an extractive practice that often overlaps with commercial fishing interests.

Marine recreational fisheries coexist with the professional fishing sector and often operates on the same fishery resources. This fact highlights the need to incorporate recreational catch data in the assessment and management of fish stocks and the allocation of specific catch quotas by the MRF. National plans for data collection by MRF are needed. In this regard, Regulation (EC) No 1004/2017 (Council of the European Union, 2017) obliges EU member states to collect data on MRF catches following the framework of the Common Fisheries Policy (EC, 2008, 2011). Additionally, Implementing Decision (EU) 2019/909 (European Commission, 2019) sets out the species on which data collection is mandatory. Although, this data collection framework only considers annual recreational catches of a few species in the delimited fishing areas (FAO, 2020), but recently, several European countries and regions have initiated their own continuous sampling programmes for certain MRF target species (Strehlow et al., 2012; Herfaut et al., 2013; Michailidis et al., 2020). In Spain, during the past decade, several Autonomous Communities have initiated multispecies studies monitoring the activity (Ruiz et al., 2014; IFOP, 2018; ICATMAR 2020a), and the activity's magnitude and catch compositions have been described at a national level (Gordoa et al., 2019; Dedeu et al., 2019). In Catalonia, the recognition of continuous data collection has allowed the generation of specific studies, such as studies on the behavior of fishers on social media (Vitale et al., 2021).

In the long term, the collection of marine recreational fisheries data will allow to build a temporal data series on catches and species records, constituting a reliable and robust source of information for decision-making processes in eventual management strategies. The combined methodology design applied in this study allows using data from the most adequate source. While the online surveys had the potential to reach an important proportion of the total population of recreational fishers, the onsite survey could target locations, seasons, catch identification, and modalities to obtain more specific data on catches. Furthermore, another goal of this continuous monitoring is the creation of a co-management roundtable to advise on future legislation related to MRF (see ICATMAR 2021).

2
Methodology

The methodological approach used in this study incorporates information from two different sources, online and onsite surveys. The online surveys are optimal for obtaining a large number of anonymous responses. They are also an adequate tool for detecting fisher avidity patterns and to identify user trends. The large data input also allows estimating the spatial and seasonal distribution of the activity. The main lacking point of the online methodology is the low reliability of catch data, which can be overcome by the complementary onsite survey designed to estimate catch compositions from direct observations of the different coastline typologies within the Catalan coastline.

Due to past limitations with the managing of the online surveys, the previous report on the continuous monitoring of marine recreational fishing in Catalonia (ICATMAR, 2021) analysed the data collected during the period from July 2020 to June 2021. In order to be aligned with the analysis periods used in the rest of ICATMAR's reports (ICATMAR, 2020a; ICATMAR, 2021), the present report analyses the data collected from January 2022 to December 2022. In addition, to be able to compare the 2022 with the 2021 data, the 2021 analyses have been reworked to fit the new timeframe (January 2021 to December 2021).

2.1. Sudy area

The sampled area included the entirety of the Catalan coastline, which spans from its northernmost town of Portbou to the river Sènia in the south. The area had been divided into 11 sampling areas that share similar ecological and morphological characteristics regarding coastal substrate, granulometry, and the influence of rivers (Figure 1).

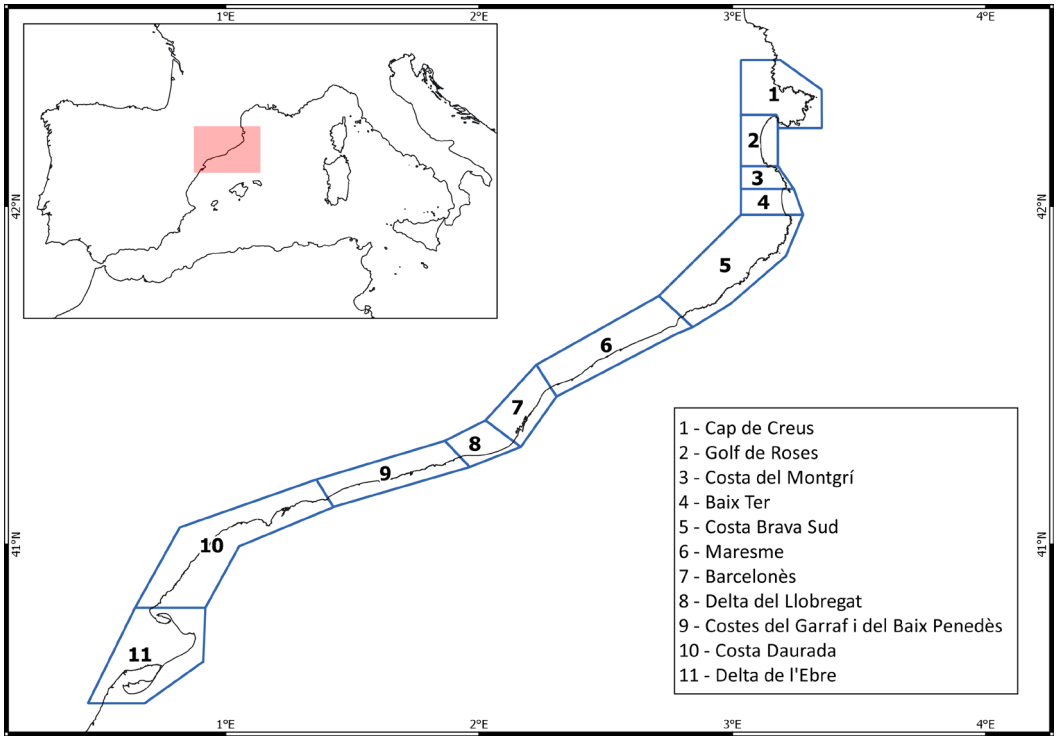

Figure 1: Division of the Catalan coastline and model of zone aggregation.

2.2. Data collection

Both the onsite and online surveys were designed to address the same questions regarding fishing modality, fishing effort, fishing yield, target species and species catch, fishing trip expenditures, socio-economic profile and human dimensions of the fishers. Online surveys additionally collected information on yearly expenditures, and onsite surveys included direct observations of the catch, as well as questions specifically regarding the fishing technique and fishing gear used.

2.2.1. Online surveys

An online survey model was programmed using an online survey development and analysis platform. Questions were programmed so as to branch out different sets of questions depending on the modality of MRF practiced. The survey was made available in four different languages (Catalan, Spanish, English and French), and could be answered using PC, tablets and mobile phones across all the main web browsers.

2.2.1.1. Survey dissemination

The licences generate a cumulative list of e-mails from which mailing lists were obtained to disseminate the survey, which were sent monthly to random subsets of available contacts. Licence holders could only be pooled from the database once a year. The volume of e-mails sent was adapted monthly with an aim to obtain around 900 monthly responses (both freshwater fishing and MRF included). Licence holders who were randomly selected received an e-mail with an individual link to the survey. Automatic reminders were sent three days and one week after the original e-mail was sent, and were programmed to be received only by individuals who had not yet responded the survey. Surveys could be started and continued within a period of two weeks. Responses were anonymized.

2.2.1.2. Survey content and architecture

The online survey was designed to direct respondents only to the questions that were relevant to their case. Since in Catalonia recreational fishing licenses are shared for the activities of freshwater and marine fishing, a first question ensured a clear distinction between freshwater and marine recreational fishers, and respondents were classified into their most practiced activity accordingly. Respondents who were classified as primarily freshwater fishers were directed to a survey that was specific to that activity. Respondents who practiced mainly MRF were directed to the survey that is analysed in this report. The first question made to in the MRF survey asked about the fishing modalities practiced, and respondents were dully classified according to their modality. In the cases in which fishers practised more than one marine recreational fishing modality, they were asked about their main practiced modality, and were directed to the corresponding subsets of questions. The survey included a set of questions on the socio-economic profile, fishing preferences such as techniques practiced and target species, outings, yearly economic expenditures, fishing indicators (effort, catch per unit effort and species caught), and fishing localities, as well as a set of questions on the human dimensions related to their fishing activity.

Considering that online answers given for metrics such as fishery indicators are prone to be significantly affected by memory and perception biases, questions on these indicators were asked regarding the shortest possible time periods. A memory scanning question determined the adequacy of asking about the previous fishing outing by specifically asking when the last fishing trip was taken and whether or not the respondent remembered the outing well. Respondents who had not been

fishing during the previous month, or who did not remember well their last outing were discarded towards the follow-up questions regarding the fishing locality, species caught and daily expenses during the latest fishing trip. Questions regarding fishing effort were asked in two different ways: firstly, fishers were asked how many fishing trips they had taken during the past four weeks (to allow seasonal fishing effort estimations). Then, they were asked about the total fishing days during the past year (to allow the classification of fishers into avidity classes).

2.2.2. Onsite survey

The onsite surveys contained the same question blocs as the online survey, with the exception of questions on human dimensions, yearly expenses (see ICATMAR, 2021, Annex II), and the added information specific to the trip. All surveys were conducted by technical staff with personal experience in recreational fishing and species identification skills. During the surveys, the staff interviewed fishers following a survey questionnaire, and, with the permission of the fishers, they would identify and measure the catches.

There were three different sampling types were carried out: surveys at ports, on foot, and by boat. The sampling design included one sampling day per zone for each season in ports (total 44 sampling days), and one sampling day per zone and season undertaken either by foot or by boat depending on the area (another 44 sampling days). This amounted to a survey design with a minimum of 88 sampling days per year, but additional sampling efforts were made to cover for survey outings with low or null responses. Accounting for repeated sampling outings, the total number of sampling days amounted to 108 in each of the two years studied. Sampling days were assigned randomly for each zone and within a season, but respecting a distribution of 30% of surveys being conducted on weekdays and 70% on weekends and public holidays. This was done in accordance with the distribution of the MRF effort known in Catalonia (ICATMAR, 2020a).

The surveys conducted at ports were used for boat fishers and spearfishers initiating the activity from a boat. Boat fishers entering the port were intercepted and surveyed, whether they were angling from the boat or used the boat to access spearfishing grounds. Survey trips were attributed to the busiest port within each of the 11 areas. The surveys on foot and on boat were used for boat angling and spearfishers who initiate the activity from land. These two types of sampling were chosen depending on the difficulty to access the main fishing areas and the presence or absence of underwater reefs in the sampling area. Samplings done on foot surveyed shore anglers fishing on beaches, rocks and jetties, as well as spearfishers exiting the waters at the end of their activity. These surveys consisted on walking along the most frequented sites in the area and surveying all the anglers encountered along the route. Sampling by boat was carried out on a speedboat sailing along the coast, which surveyed spearfishers in the water and shore anglers located on the rocks and/or breakwaters. Each sampling trip lasted 6 hours, and was carried out prioritizing the peak effort of each fishing mode as identified in the pilot study (ICATMAR, 2020a). For the surveys at ports, midday was used as the equator of the working hours; for the surveys conducted by foot, sunset was prioritized as the middle point of the working day, and for the surveys done by boat, the working hours extended from sunrise to midday.

2.3. Data processing and analysis

The data collected from online and onsite survey methods was stored in a database and submitted to a process of quality control. Extreme and implausible values were identified and removed from the study.

Firstly, the sources if the data analysed come from three methodologies (onsite surveys, online surveys, and licence registry), and these are combined in order to produce of the estimated values used in the analysis.

Since in Catalonia freshwater and marine recreational angling share a common "surface angling" licence, the volume of participants in each activity had to be estimated using the proportions of participants obtained in the online surveys applied to the total number of active licences during the study period. Then, those classified into MRF were segmented into their main angling modality (shore or boat angling) based on the percentages obtained in the online survey responses. It is worth noting that these surface angling licences can be issued for one single day, for 15 days, for a whole year, or for 2, 3, and 4 years (see section 4, Table 1). Spearfishing has its own specific license, always with annual validity. The number of unlicensed participants for each three modalities was not included in the total results. However, in order to obtain a more realistic number of unlicensed activities, a pilot study was carried out with police and rural officers (see section 6.).

The geographical distribution of fishing effort by season was estimated using the online effort results of the aggregate number of trips per zone. This allowed extrapolating values of total catch per season to each of the 11 zones (see Figure 1). Currently, work is being done on the frequency of annual fishing days (see section 4.2). In this case, we represent this question via barplot with a trend line (equation: y=A*X^b), to smooth the "memory values".

Both surveys classified fishers of each modality into one of five different avidity classes based on the responses on annual effort:

- zero avidity; fishers who reported not having practiced the activity for at least one year
- sporadic avidity; attributed to all one-day fishing licence-holders and to those who declared fishing up to twice a year in the surveys
- low avidity; attributed to those who reported fishing between 3 and 19 outings during the past 12 months
- medium avidity; those who went fishing between 20 and 49 days
- high avidity; those who had had more than 50 fishing trips throughout the past 12 months

Information on Catch Per Unit Effort (CPUE) was estimated by Harvest Per Unit Effort (HPUE) for each avidity group within each season, by using daily catch rate information from the onsite surveys. Similarly, effort estimates were produced for each avidity class within each season using effort values from the online survey (the monthly effort values were extrapolated to seasonal activity by multiplying the declared monthly outings by 3).

A value of total catch per average fisher of each avidity class within each season was estimated as the product of the CPUE and effort values of these crossed categories. Then, the volume of participants attributed to each avidity class was estimated as the product of the total participation by modality and the percentage of each avidity class based on the online responses. This allowed estimating a value of total catch for each avidity class within each modality and for each season. Total seasonal modality catches were then distributed by species using the seasonal catch compositions obtained from the onsite survey.

3

Response obtained from the surveys

(2021-2022)

3.1. Response to the onsite survey

The onsite survey campaign obtained a total of 1 507 responses in 2021 and 1 404 in 2022 (Figure 2). Of the total survey respondents in 2021, 95% resided in Catalonia, 4% outside of Spain and 1% in other parts of Spain. Then, in 2022, 91% resided in Catalonia, 6% outside of Spain and 3% in other parts of Spain.

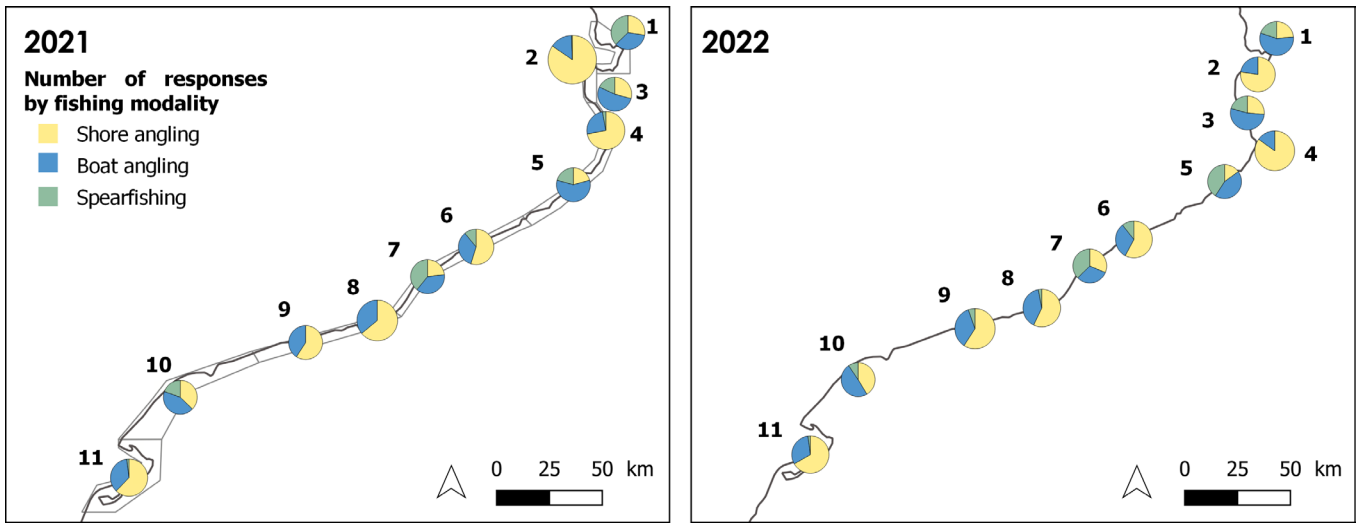

Figure 2: Proportion of responses for each fishing modality in the onsite surveys conducted in each of the 11 zones on 2021(left) and 2022(right). The size of each pie chart is relative to the total number of onsite surveys conducted in each of the zones: 1. Cap de Creus, 2. Golf de Roses, 3. Costa del Montgrí, 4. Baix Ter, 5. Costa Brava Sud, 6. Maresme, 7. Barcelonès, 8. Delta del Llobregat, 9. Costes del Garraf, 10. Costa Daurada and 11. Delta e l'Ebre.

As for the onsite survey responses in 2021, 780 were from shore anglers, 554 from boat anglers, and 173 from spearfishers (Figure 3). Conversely, in 2022 there were 726 responses from shore anglers, 503 from boat anglers, and 175 from spearfishers.

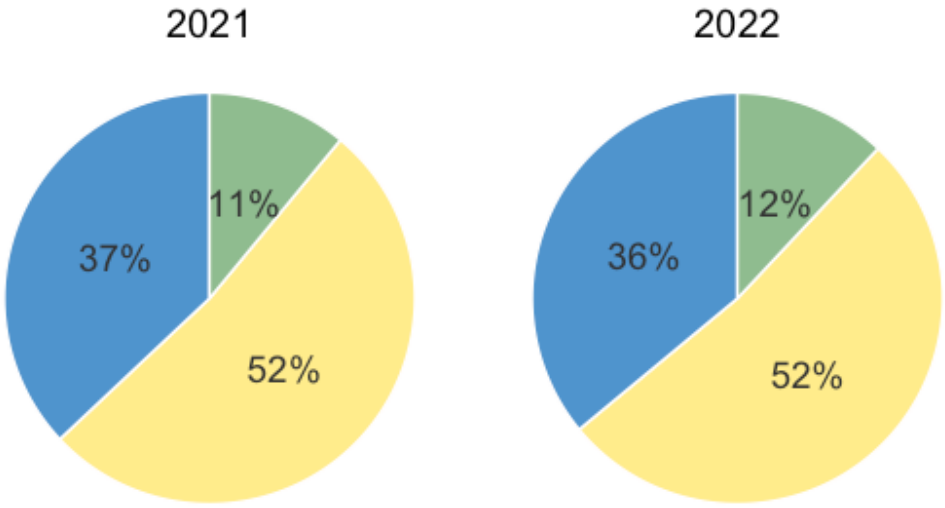

Figure 3: Percentage of the three fishing modalities of the fishers surveyed in the onsite sampling. Yellow: shore angling; blue: boat angling; green: spearfishing.

Regarding the nationalities of the onsite survey respondents, in 2021 89.2% were from Spain, 6.8% from the rest of Europe (mainly from France), 3.1% from African countries (i.e., Morocco and Algeria), 0.7% from South American countries and 0.1% from Asian countries (i.e., Russia and China) (Figure 4). However, in 2022 87.3% of the respondents were from Spain, 9.1% from the rest of Europe (mainly from France and Italy), 1.7% from African countries (i.e., Morocco and Algeria), 1.1% from South American countries, 0.4% from Asian countries (i.e., Russia and China) and 0.4% from the United Kingdom.

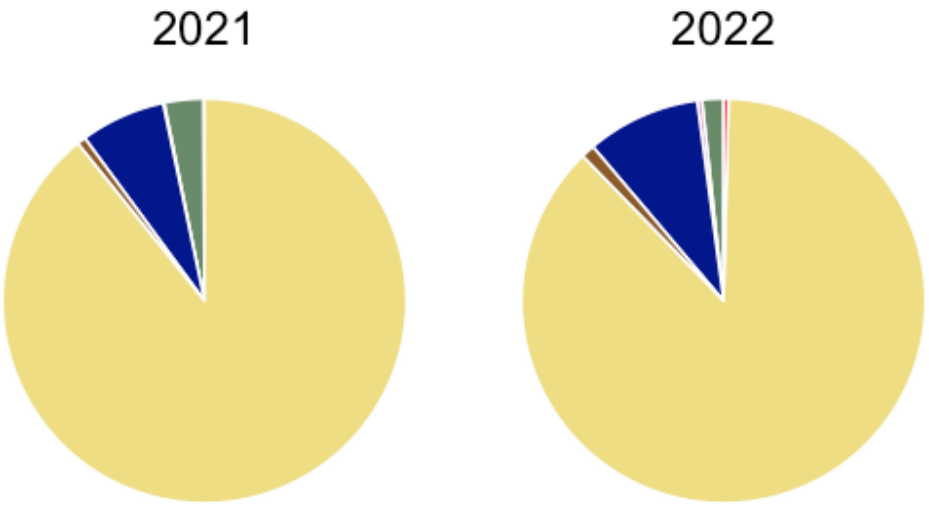

Figure 4: Percentage of the nationalities of the fishers surveyed in the onsite sampling. Green: Africa (i.e., Morocco and Algeria); rose: Asia (i.e., Russia and China); purple: EU (mainly France in 2021 and France and Italy in 2022); brown: SA (South American countries); yellow: Spain; red: UK (United Kingdom).

3.2. Response to the online surveys

As for the online surveys, the results are similar for the two years compared, although some slight differences are present. In 2021 a total of 11 992 answers were obtained: 8 638 of the respondents declared practicing primarily marine recreational fishing (72%) and 3 354 practised mostly freshwater recreational fishing (28%) (Figure 5). On the other hand, in 2022 a total of 9 748 online surveys were responded: 6 891 of the respondents declared practicing mostly MRF (70%), while 2 947 declared practicing mainly continental recreational fishing (30%).

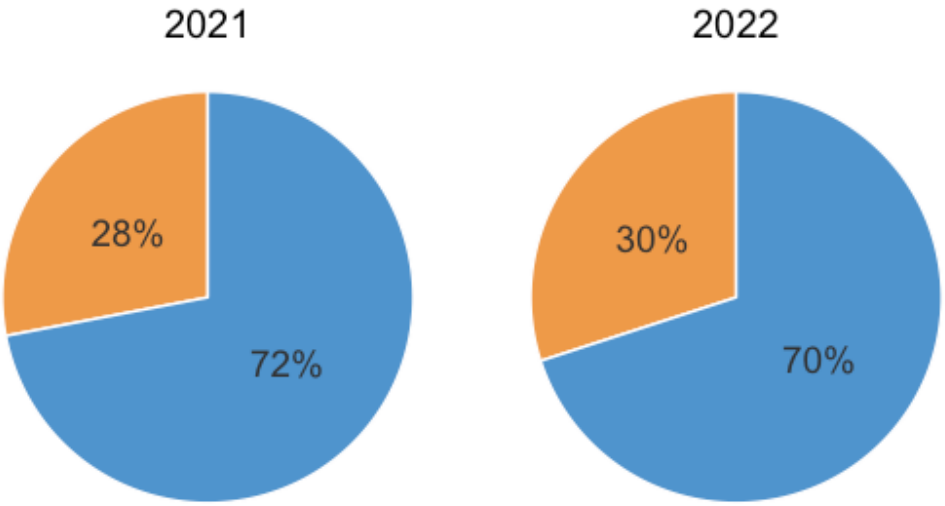

Figure 5: Percentage of answers to online surveys. Orange: continental recreational fishing; blue: marine recreational fishing (MRF).

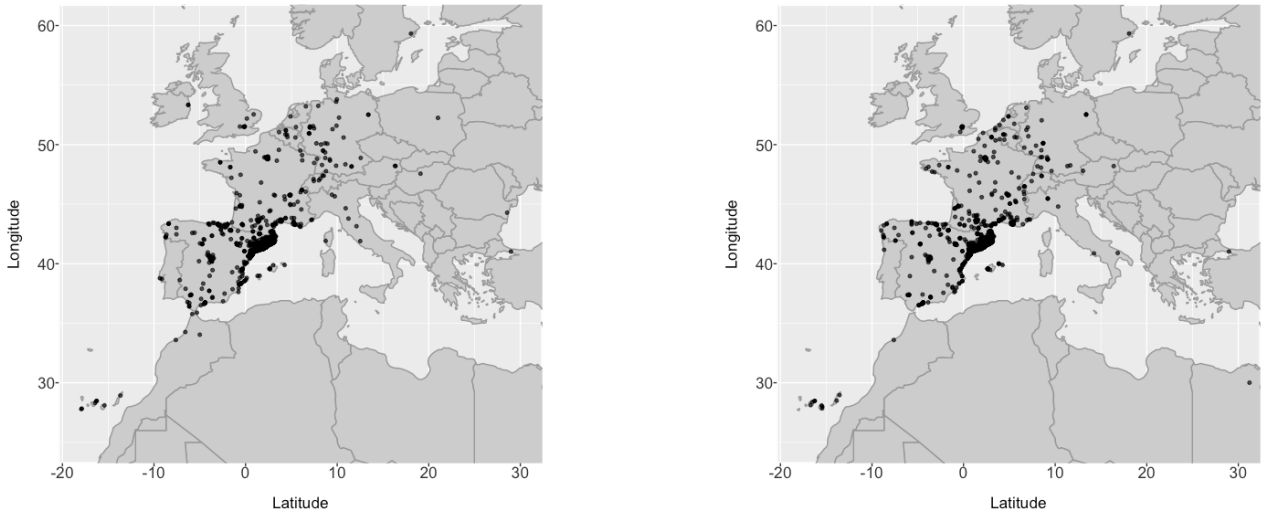

Figure 6: Location of devices used to respond to MRF online surveys in (left) 2021 and (right) 2022.

In both 2021 and 2022, MRF respondents mainly answered the survey from devices that were physically located in Catalonia, but many others responded from other locations; namely, from the most populated regions of Spain, and from the south of France (Figure 6; for more information on the international response location see Annex I). Comparing the two years, in 2021 there was a higher concentration of answers located in the region of Valencia, Spain, and in Belgium, while in 2022 more answers were registered in the north of Spain and in different spots throughout the area of France.

From the 8 638 online survey responses classified into MRF in 2021, 276 users did not continue the survey past the first question and could not be further classified into a fishing modality, whereas in 2022 out of the 6 801 responses classified into MRF, 225 responses were discarded for the same reason (Figure 7). The remaining surveys, 8 362 and 6 576 for 2021 and 2022 respectively, provided enough information to estimate the proportions of fishing modalities. A total of 296 respondents in 2021 and 199 in 2022 declared practicing the three modalities (i.e., shore angling, boat angling and spearfishing).

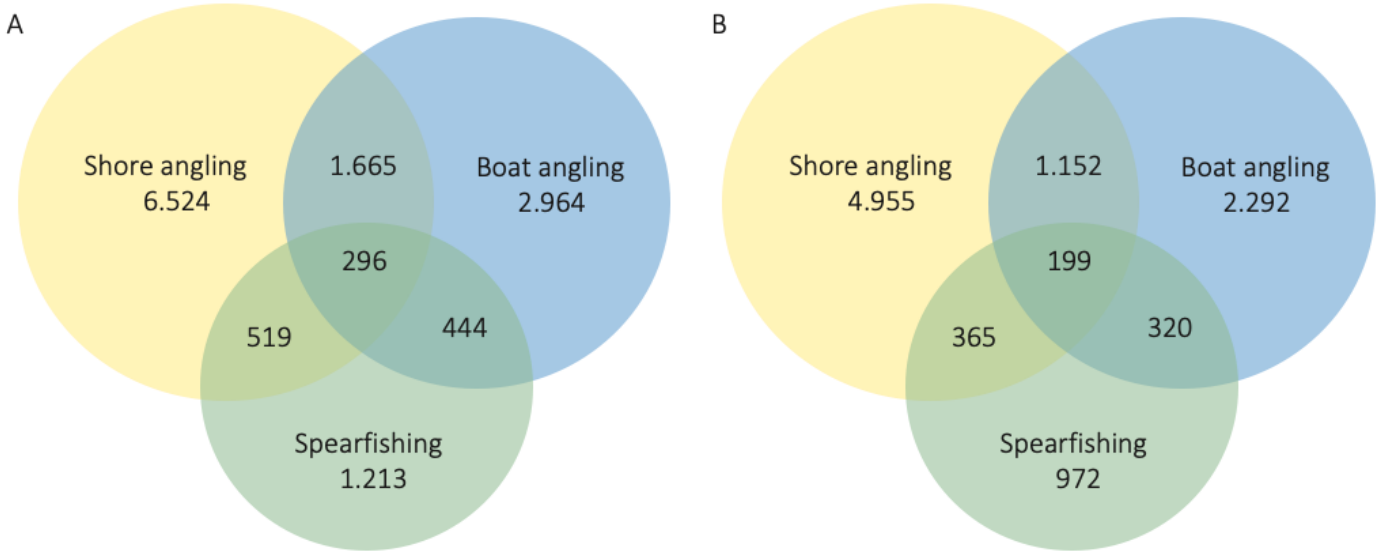

Figure 7: Number of marine recreational fishers by modality from the online surveys in (A) 2021 and (B) 2022.

In 2021 a total 6 524 respondents declared practicing shore angling, of which 1 665 also practiced boat fishing, and 519 also spearfished. A total 2 964 responses were obtained from boat fishers, of which 444 respondents practised both boat fishing and spearfishing. The total amount of responses from spearfishers was 1 213. By contrast, in 2022 a total 4 955 respondents declared practicing shore angling, of which 1 152 also practiced boat fishing, and 365 also spearfished. A total 2 292 responses were obtained from boat fishers, of which 320 respondents practised both boat fishing and spearfishing. The total amount of responses from spearfishers was 972.

In regards to the main fishing modality declared by the respondents, in 2021 5 682 answers were from shore anglers (68%), 1 849 from boat anglers (22%) and 831 from spearfishers (10%) (Figure 8). On the other hand, in 2022 4 291 respondents declared shore angling as their main modality (65%), 1 550 declared it was boat angling (24%) and 735 spearfishing (11%).

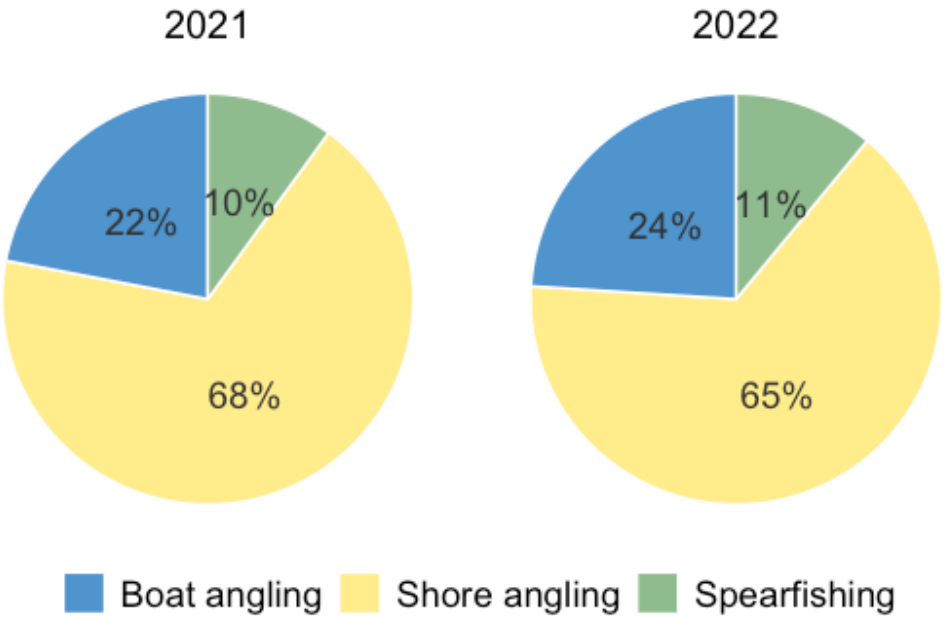

Figure 8: Percentage if practitioners based on the main fishing modality of each respondent in (A) 2021 and (B) 2022.

4
Activity volume

4.1. Analysis of recreational fishers in Catalonia through the license register

The total number of active surface angling, both marine and freshwater, and spearfishing licenses emitted during 2021 was 57 592 and 2 758, respectively. Using the proportion of freshwater to marine responses from the first scanning question of the online survey, a total 41 466 surface angling licences were estimated to be used primarily for MRF while 16 126 corresponded to freshwater fishers. Of the MRF licenses, the proportion of shore and boat angling (75 and 25% respectively) was obtained from the second classifying question and was used to estimate the surface licenses that could be attributed to each modality. Spearfishing values were obtained directly from the specific spearfishing license registry. In summary, in 2021 a total of 44 224 MRF licenses were emitted: 31 100 corresponded to shore anglers, 10 367 to boat anglers and 2 758 to spearfishers (see Table 1).

Taula 1. Classification (type of license) of the total Surface licenses aimed at marine recreational fishers.

	Shore angling		Boat angling	
	2021	**2022**	**2021**	**2022**
One day	2 457	2 642	819	977
Two day	715	935	238	346
Fifteen days	1 586	2 674	529	989
Anual	20 961	20 895	6 987	7 728
Plurianual (up to 4 years)	5 380	4 547	1 793	1 682
Total	**31 100**	**31 693**	**10 367**	**11 722**

On the other hand, it is worth noting the increase in the number of licenses emitted in 2022 for each modality compared with 2021. The total number of active surface angling, both marine and freshwater, and spearfishing licenses emitted during 2022 was 62 022 and 2 985, respectively. Using the proportion of freshwater to marine responses from the first scanning question of the online survey, a total 43 415 surface angling licences were estimated to be used primarily for MRF while 18.607 corresponded to freshwater fishers. Of the MRF licenses, the proportion of licenses attributed to shore and boat angling were 73 and 27% respectively. In summary, a total of 46 400 MRF licenses were emitted: 31 693 corresponded to shore anglers, 11 722 to boat anglers and 2 985 to spearfishers.

The estimation of active marine recreational fishers takes into account fishers with 2, 3 and 4 years licences issued prior to the years studied, respectively. This is influenced by the percentage, not included in this report, of recreational fishers with a license issued in another autonomous community (11%, a percentage analysed from the pilot regional police test).

4.2. Analysis of avidity class about fishing days on marine recreational fishers

Figure 9 shows the frequency of reported fishing days on marine recreational fishers, i.e., they are the response to the question "How many days have you gone fishing in the last 12 month?", collected during the onsite surveys for 2021 and 2022 together. As the responses come from onsite surveys, the likelihood of surveying fishers who fish more often is higher. Therefore, there is a higher proportion of fishers who declared being in the medium and high avidity classes (between 20 and 50 days per year), with some reporting fishing up to 350 per year.

Figure 10 shows the frequency of reported fishing days on marine recreational fishers, i.e., they are the response to the question "How many days have you gone fishing in the last 12 month?", collected during online surveys for 2021 and 2022 together. In contrast to the avidity classes gathered during onsite surveys, the avidity class 0 (no fishing days per year) is clearly shown. In addition, there is a higher proportion of fishers who declared fishing between 5 and 15 days per year, a low avidity class. Furthermore, the highest number of fishing days declared during online surveys is 150.

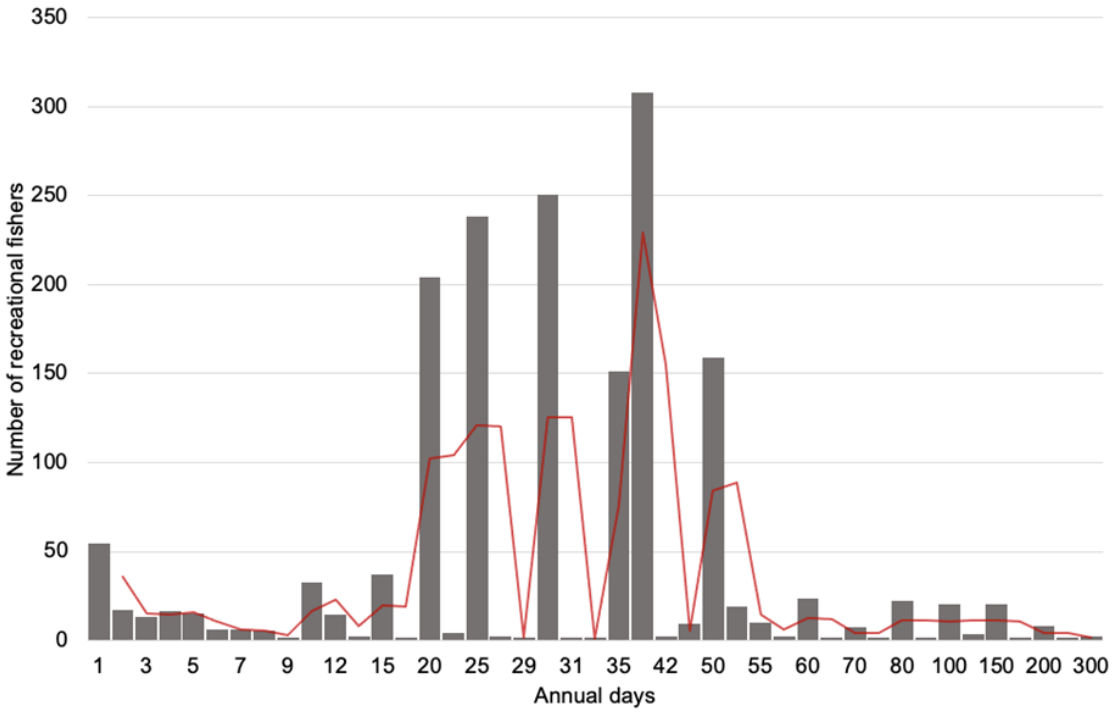

Figure 9: The fishing days on marine recreational fishers collected during onsite surveys, 2021 and 2022 together. Bars, number of marine recreational fishers; line, trend.

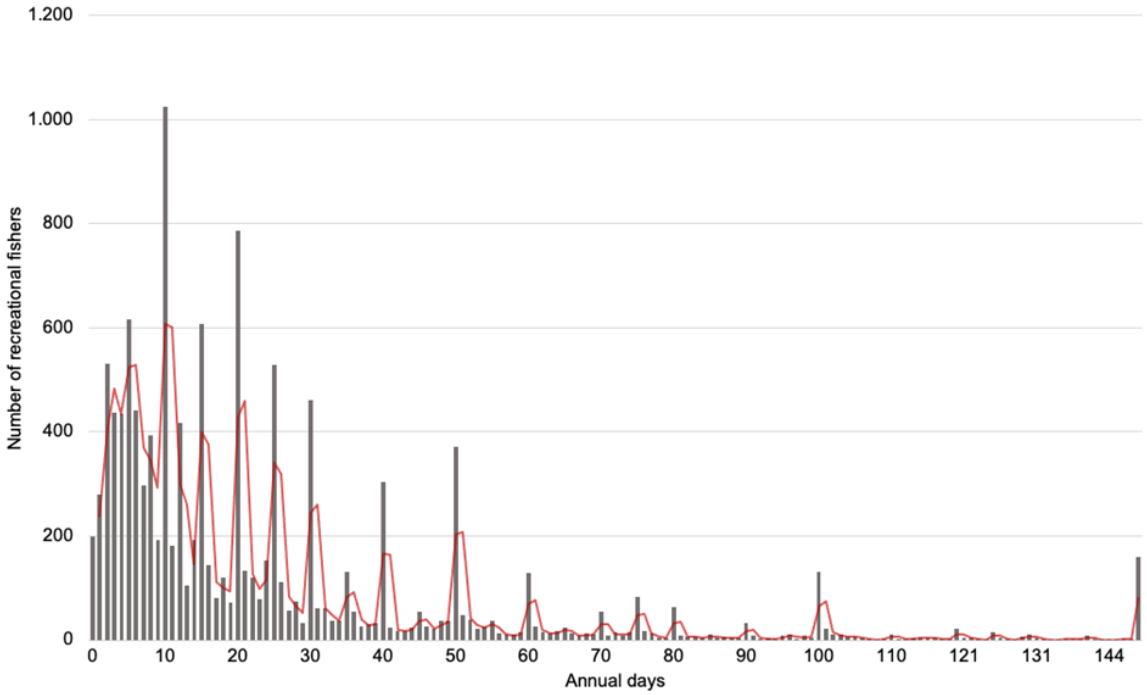

Figure 10: The fishing days on marine recreational fishers collected during online surveys. Bars, number of marine recreational fishers; line, trend

5

Marine recreational fishing modality analysis

Shore angling

5.1. Shore angling

5.1.1. Fishing effort

The results of the shore angling effort are based on annual effort distributions from the online surveys, which allowed to classify respondents into avidity classes based on their declared fishing effort during the past 12 months (see Annex II). The online survey only represents license-holders. Therefore, the effort distributions from the online surveys were extrapolated only to licensed fishers.

Table 2. Avidity class distribution of licensed fishers for shore recreational anglers.

	2021	2022
Zero	16%	14%
Sporadic (1 -2 days)	8%	7%
Low (3 -19 days)	44%	43%
Medium (20 -49 days)	22%	24%
High (+50 days)	10%	12%

The results showed a considerable proportion of individuals holding a recreational fishing license whom did not make any use of it during the years 2021 and 2022 (16% and 14%, respectively). For the two years, the majority of anglers showed low avidity effort patterns (44% and 43%, respectively). The medium avidity class holds about 23% of the fishers whereas the response rate for shore anglers' high avidity was 10% and 12% for 2021 and 2022, respectively (Table 2).

The responses of the percentages obtained from the surveys were extrapolated to the number of active fishers to estimate the number of anglers by avidity category. The year-to-year variation was very small, around 2% (Table 3).

Taula 3. Estimate total number of shore anglers of each years.

	2021	2022	Variation	% variation
Zero	4 152	3 589	-563	-13.6
Sporadic (1 -2 days)	5 233	5 274	41	0.8
Low (3 -19 days)	13 287	13 674	387	2.9
Medium (20 -49 days)	5 823	6 028	205	3.5
High (+50 days)	2 604	3 128	524	20.1
Total	**31 100**	**31 693**	**593**	**1.9**

Reported annual fishing effort for shore anglers who went fishing at least once during 2021 showed an average of 18 fishing days per year, with a similar periodicity through the different seasons, ranging from 20 days per year in spring and autumn to 17 days per year in winter. Similarly, reported annual fishing effort for shore anglers who went fishing at least once during 2022 showed an average of 21 fishing days per year, also with a similar periodicity through the different seasons ranging from 23 days per year in autumn to 19 days per year in spring. It is possible that the slightly higher number of fishing days in winter 2022 may be due to the fact that nicer weather started earlier. Coincidentally, the winter months of 2021 still had some restrictions due to the Covid-19 pandemic.

The evaluation of the frequency of fishing days from the online surveys by answering the question: How many times have you gone fishing in the last 4 weeks? is reported as a monthly average by avidity class per season in 2021 and in 2022 (Table 4).

There is a similar tendency for both years, with the highest average obtained from the high avidity class, and it diminishes as the class progresses towards the sporadic category.

Table 4. Monthly average from 1 month analysed through online surveys by answering the question: *How many times have you gone fishing in the last 4 weeks?*

Year 2021	Zero	Sporadic	Low	Medium	High
Winter	0	0.01±(0.35)	0.16±(0.67)	0.94±(1.98)	7.46±(4.50)
Spring	0	0.09±(0.51)	1.01±(1.71)	2.71±(2.84)	8.01±(5.18)
Summer	0	0.14±(0.76)	1.58±(2.11)	3.83±(4.23)	9.42±(5.84)
Autumn	0	0.06±(0.41)	0.62±(1.48)	2.01±(2.86)	8.09±(5.95)
Year 2022	**Zero**	**Sporadic**	**Low**	**Medium**	**High**
Winter	0	0.05±(0.53)	0.50±(1.35)	1.83±(3.10)	7.96±(5.85)
Spring	0	0.09±(0.73)	0.80±(1.34)	2.47±(2.95)	7.22±(5.09)
Summer	0	0.14±(0.74)	1.36±(1.92)	3.52±(3.51)	9.23±(6.08)
Autumn	0	0.08±(0.50)	0.78±(1.91)	2.17±(2.69)	8.39±(5.36)

5.1.1.1. Effort distribution

The north of Catalonia (from Cap de Creus to Costa Brava) is characterized by its rocky coastline and a relative scarcity of sandy beaches. During 2021, in winter, 23% of shore anglers spent their fishing days in the north of Catalonia, whereas in spring, summer and autumn it was 27%, 28% and 26%, respectively. The central and southern beachy zones of the Catalan coastline (from Maresme to Delta de l'Ebre) are much more frequented by shore anglers. The zones accumulating the most fishing days were the Costes del Garraf, the Costa Daurada and the Maresme, with 88 731, 81 797 and 75 670 fishing days during 2021, respectively. In most areas, summer was the most popular season for shore angling, up to 205 588 fishing days per year. During the bathing season (June 15th to September 15th) beaches do not allow fishing at daytime hours, generally restricting fishing from the coast to more isolated and unregulated sandy beaches and other coastal areas such as breakwaters and rocky shores (Figure 11).

Results by 2021 show a considerable level of activity in the most highly populated central region of the studied area: the zones surrounding the Metropolitan Area of Tarragona and the densely populated areas of Costa Daurada and the Costes del Garraf, concentrate 30% of the total fishing activity. Overall, the shore angling effort accumulated an estimated of 562 873 fishing trips per year.

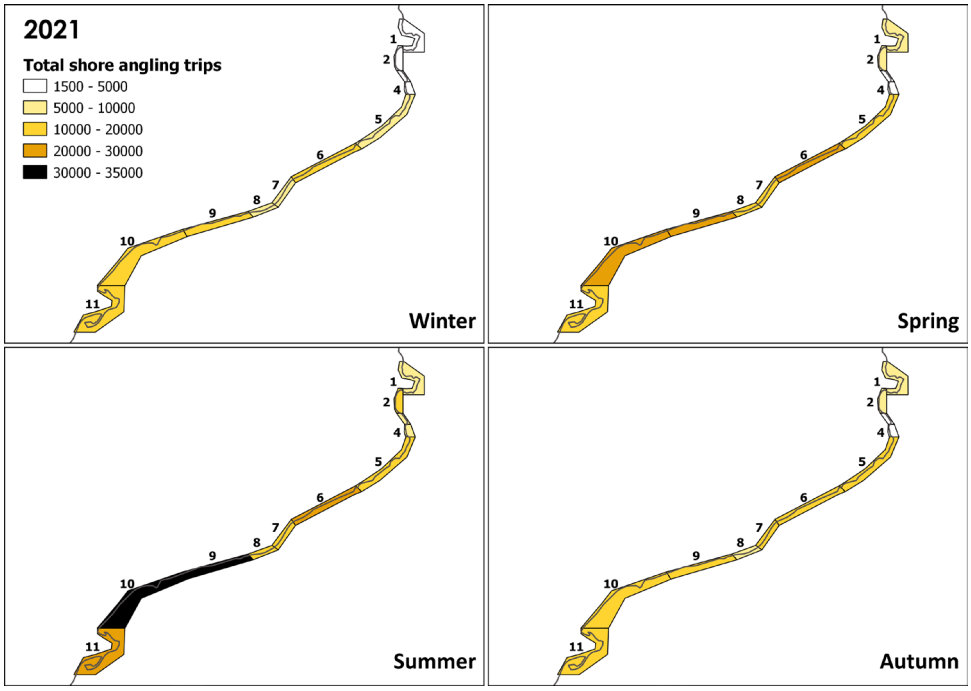

Figure 11: Total shore fishing trips during 2021 per zone during each season. In this analysis we do not consider the areas where fishing is not allowed.

The average daily shore angling trips per kilometre in 2021 show the degree to which this fishing activity is unevenly distributed at a temporal and geographical scales (Figure 12; Annex II). The most intensely fished zone is also the one with the most densely populated beaches in the city of Barcelona and its metropolitan surroundings, with a yearly average of 7.3 fishing trips per kilometre (Figure 12). Considering the differences in seasonal activity, the spatial distribution of shore fishers is fairly consistent across seasons.

Following the same analytical pattern, in 2022 during winter, 27% of shore anglers spent their fishing days in the north of Catalonia, whereas in spring it was 26%, and in summer and autumn 23% each season. The more central and southern beachy zones of the Catalan coastline (from Maresme to Delta de l'Ebre) are much more frequented by shore anglers. During winter, 73% of shore anglers spent their fishing days in some zone of the central or southern Catalonia, whereas in spring it was 74%, and in summer and autumn 77% each sea-

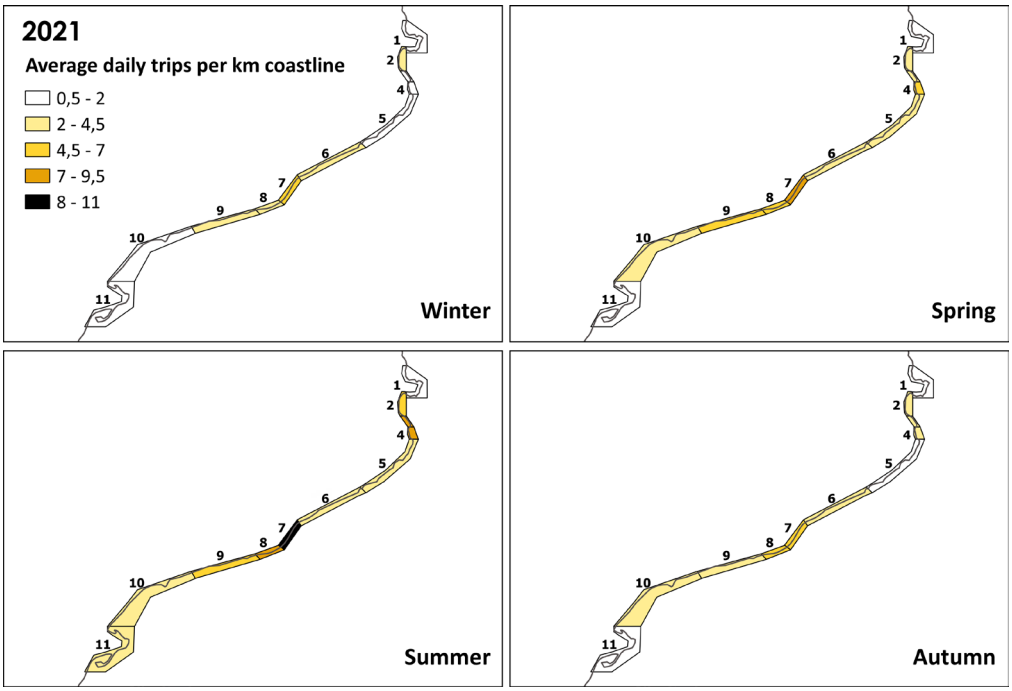

Figure 12. Average number of daily fishing trips during 2021 per kilometer coastline within each season.

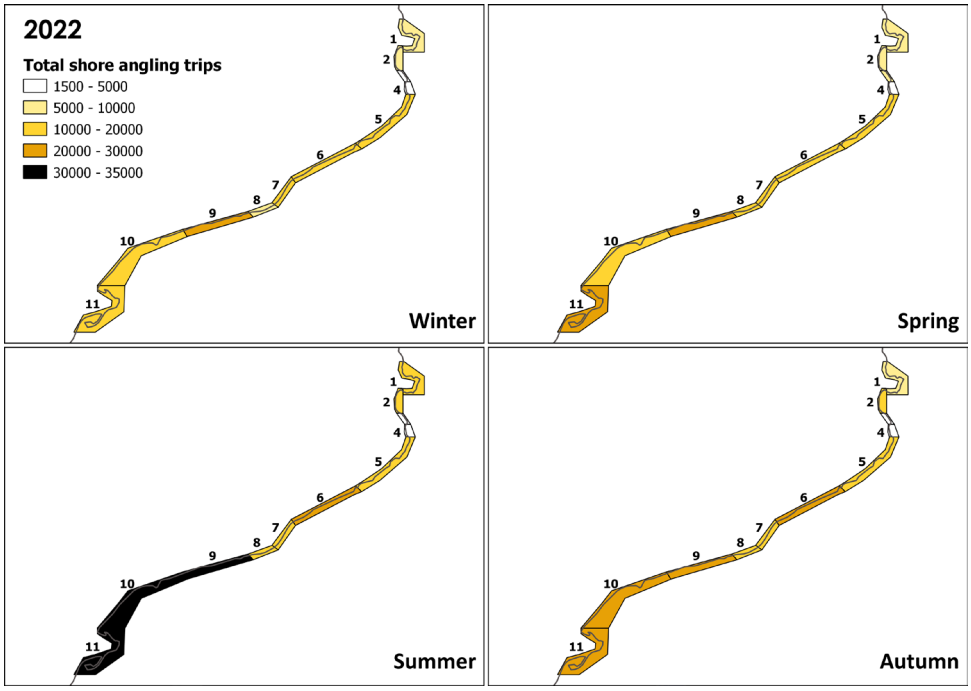

Figure 13. Total shore fishing trips during 2022 per zone during each season. In this analysis we do not consider the areas where fishing is not allowed.

son. The zones accumulating most fishing days were Costes del Garraf, Delta de l'Ebre, Costa Daurada and Maresme, with 95 622, 93 986, 93 929 and 91 034 fishing days during 2022, respectively (Figure 13). In most areas, summer was the most popular season for shore angling (208 411 fishing days per year).

Overall, the shore angling effort, accumulated an estimate 645 588 fishing trips per year.

The average daily shore angling trips per kilometre in 2022 show the degree to which this fishing activity is unevenly distributed at a temporal and geographical scale (Figure 14; Annex II). The most intensely fished zone is also the one with the most densely populated beaches in the city of Barcelona and its metropolitan surroundings, with a yearly average of 8.4 fishing trips per kilometre (Figure 14). Considering the differences in seasonal activity, the spatial distribution of shore fishers is fairly consistent across seasons.

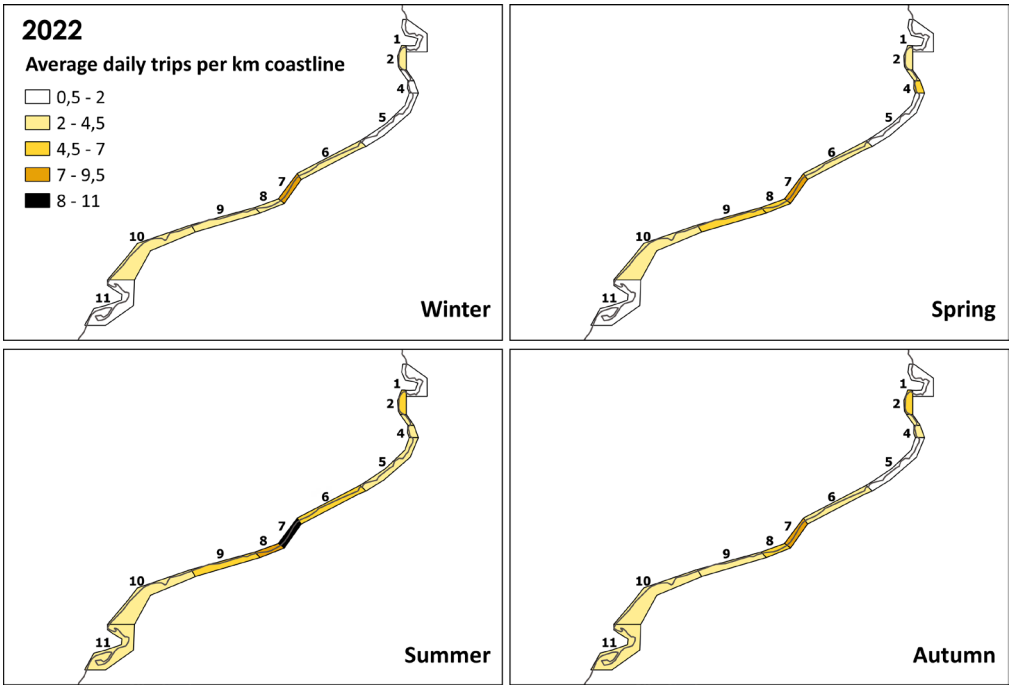

Figure 14. Average number of daily fishing trips during 2022 per kilometer coastline within each season.

5.1.2. Fishing yield

Fishing yield was analysed using catch per unit effort (CPUE) measured in kilograms caught per day fished. The fishing yield values for shore anglers showed the lowest fishing productivity for both years (0.30±0.94 kg/day and 0.44±1.16 kg/day in 2021 and 2022, respectively), followed by boat anglers and spearfishing, as detailed in Table 5. The fishing yield values from shore angling significantly differed from the other two fishing modalities (p-value<0,05). Information on CPUE values from the three fishing modalities together for each year can be found in Annex III.

Table 5. Means and standard deviations per fishing modality and per year.

	Shore angling		Boat angling		Spearfishing	
	2021	2022	2021	2022	2021	2022
Mean	0.29	0.44	0.71	1.07	1.32	1.66
SD	±0.94	±1.16	±1.24	±2.09	±1.89	±1.69

Comparing the two years studied we see that there was a significant difference (p-value=0.003) using a Wilcoxon rank with continuity correction. Therefore, there was a difference in CPUE for shore angling fishing between the two years studied. In detail, the average CPUE in 2022 was higher (0.44±1.16) than that from 2021 (0.30±0.94; Figure 15).

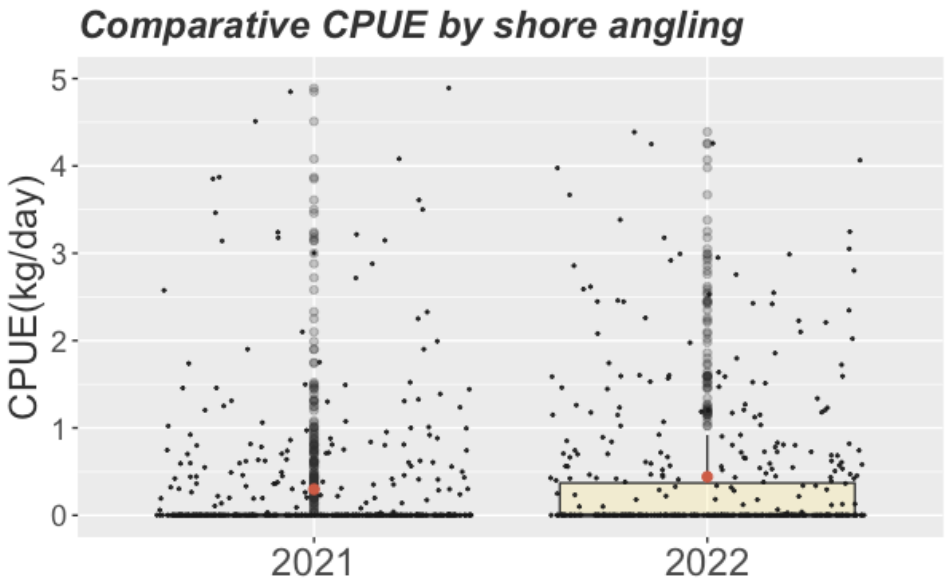

Figure 15: CPUE by 2021 and 2022 for shore angling. The red rot indicates the mean, the horizontal black line represents the median the boxes represent the interquartile ranges (25 – 75%) and the vertical line represents the 90% spread of the data.

However, there were no significant differences (p-value=0.578) in CPUE for shore angling fishing among seasons in 2021. In detail, the average CPUE was 0.24±0.98, 0.36±1.12, 0.22±0.66 and 0.37±0.98 for winter, spring, summer and autumn, respectively (Figure 16).

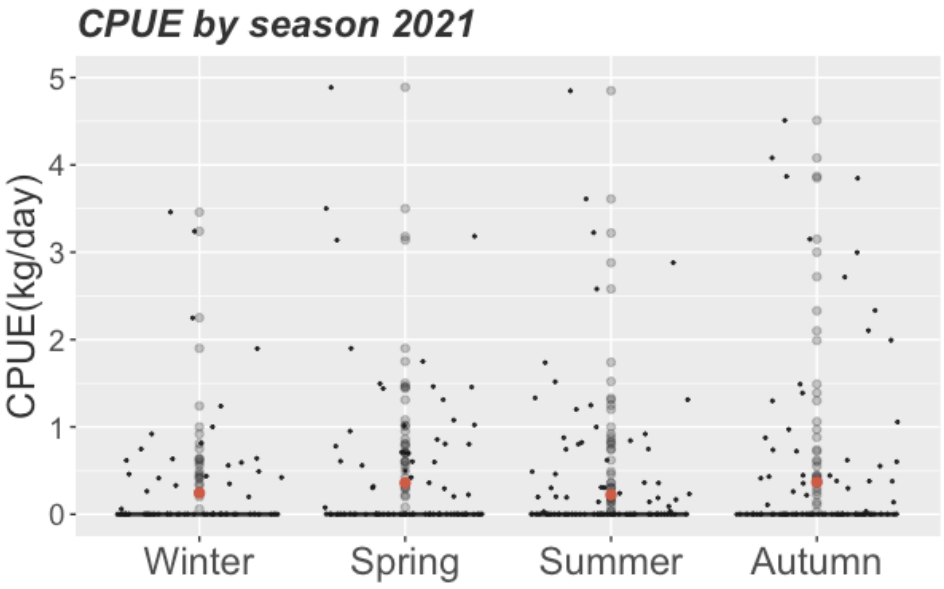

Figure 16: CPUE by season in 2021. The red rot indicates the mean and the vertical line represents the 90% spread of the data.

Similarly, there were no significant differences (p-value=0.667) in CPUE for shore angling fishing among seasons in 2022. In detail, the average CPUE was 0.31±0.79, 0.62±1.78, 0.37±0.76 and 0.44±0.94 for winter, spring, summer and autumn, respectively (Figure 16).

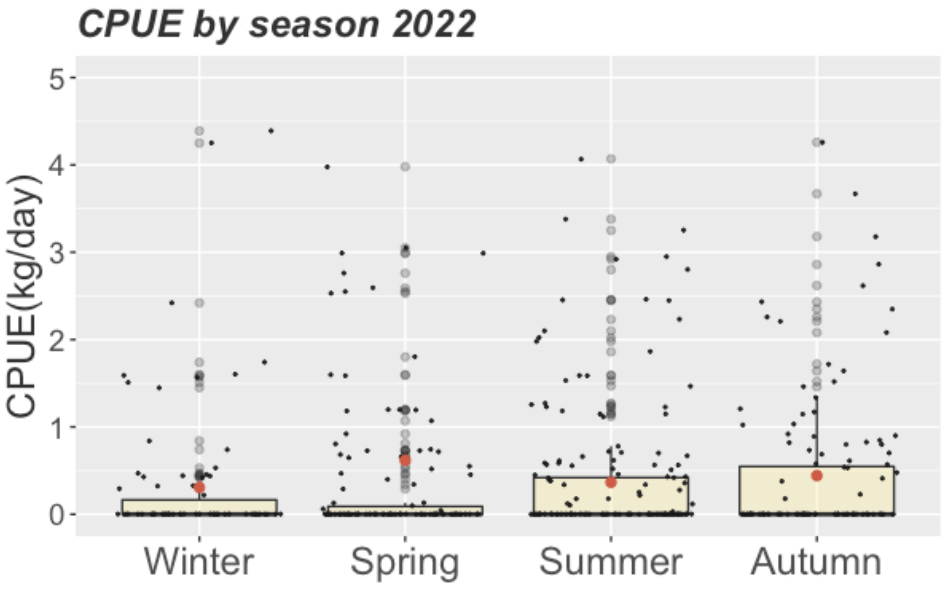

Figure 17: CPUE by season in 2022. The red rot indicates the mean, the horizontal black line represents the median the boxes represent the interquartile ranges (25 – 75%) and the vertical line represents the 90% spread of the data.

5.1.3. Intended target species

Recreational fishers mostly have a specific catch or set of catches in which they are interested. It must be considered the intended target species are merely a declaration of intentions, and do not necessarily reflect the eventual outcome of a fishing trip, but they can be considered an important motivation axis setting the expectations for a given fishing trip.

Accordingly, the main species group of interest of shore fishing were the Sparidae family, mainly *Sparus aurata*, different species of the genus *Diplodus spp.*, and other sparids such as *Lithognathus mormyrus*. The second most coveted intended target catch was the *Dicentrachus labrax*. Other target species include cephalopods, such as *Loligo vulgaris*, *Sepia officinalis*, and *Octopus vulgaris*.

The intended target species answers from 2022 is very similar to that from 2021 (Figure 18).

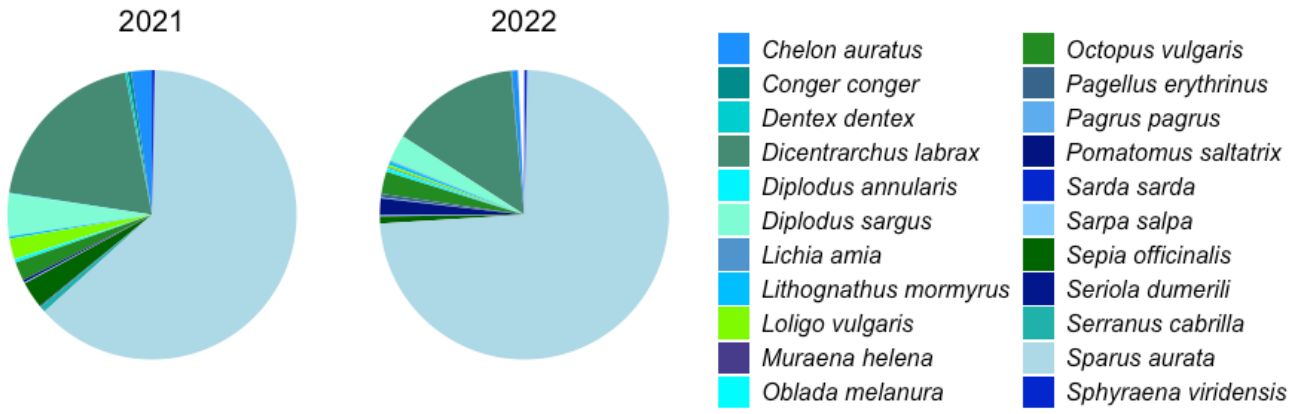

Figure 18: Percentage of species according to declared as target by shore angling in 2021 and 2022.

5.1.4. Seasonal catch composition

In the onsite sampling, a total 1 081 individual catches from shore fishing were identified from a total 45 different species during the studied years. Catch composition results show the actual catch estimates obtained from the onsite surveys. They contrast with results from target species, and it is clear that for all three fishing modalities, there is a difference between species' desirability and their actual catchability. Species' catch seasonality may also be observed, as different species are more or less available, or more or less desired during different times of the year.

The species catch compositions of shore angling represented a total of 42 different species throughout the year 2021. The highest catch diversity was found in the spring, with 26 different species observed, followed by summer and autumn with 20 different species and the lowest catch diversity was in the winter with 16 different species (Annex IV, Figure 74). This greater diversity during the warmer months, however, may be explained by the greater number of observations obtained during months with greater fishing activity. In 2022, the species catch compositions of shore angling represented a total of 37 different species. Autumn was found to be the season with the highest biodiversity, with 27 different species observations (Annex V, Figure 75; note

that only species with over 1% of the total catch are represented), followed by summer with 22, followed by spring with 21, and finally winter with 16 different species.

Catch composition results show the actual estimates obtained from the onsite surveys. There were some similarities and differences among seasons between both studied years. In winter 2021, the 26% of the catch was seabass but there were no *Spicara maena* or *Pagellus erythrinus*. Differently, in winter 2022 the catches of seabass decreased to 11.6% but S. *maena* and P. *erythrinus* were caught, being S. *maena* the most predominant species in the winter catch (35.8%). In spring, the top caught species were S. *aurata* and *Octopus vulgaris* for both years whereas in summer, the two top species were S. *aurata* and *Diplodus sargus*. Autumn has the greatest differences between both years, with different catch composition and amount. For example, *Conger conger* is only present (6.9%) in 2021 whereas *Pomatomus saltratix* and *Seriola dumerli* are only present in 2022 with abundances of 14.5% and 7.4%, respectively. In the case of *Conger conger* catches during spring was an unexpected finding; this is a catch that is sought mostly by a small group of highly specialized fishers who find the conger in jetty blocks. Its prominent role in the catches could be a product of chance, as only a handful of these specialized were encountered during the surveys but had all had especially productive outings (see Annex IV, Figure 74).

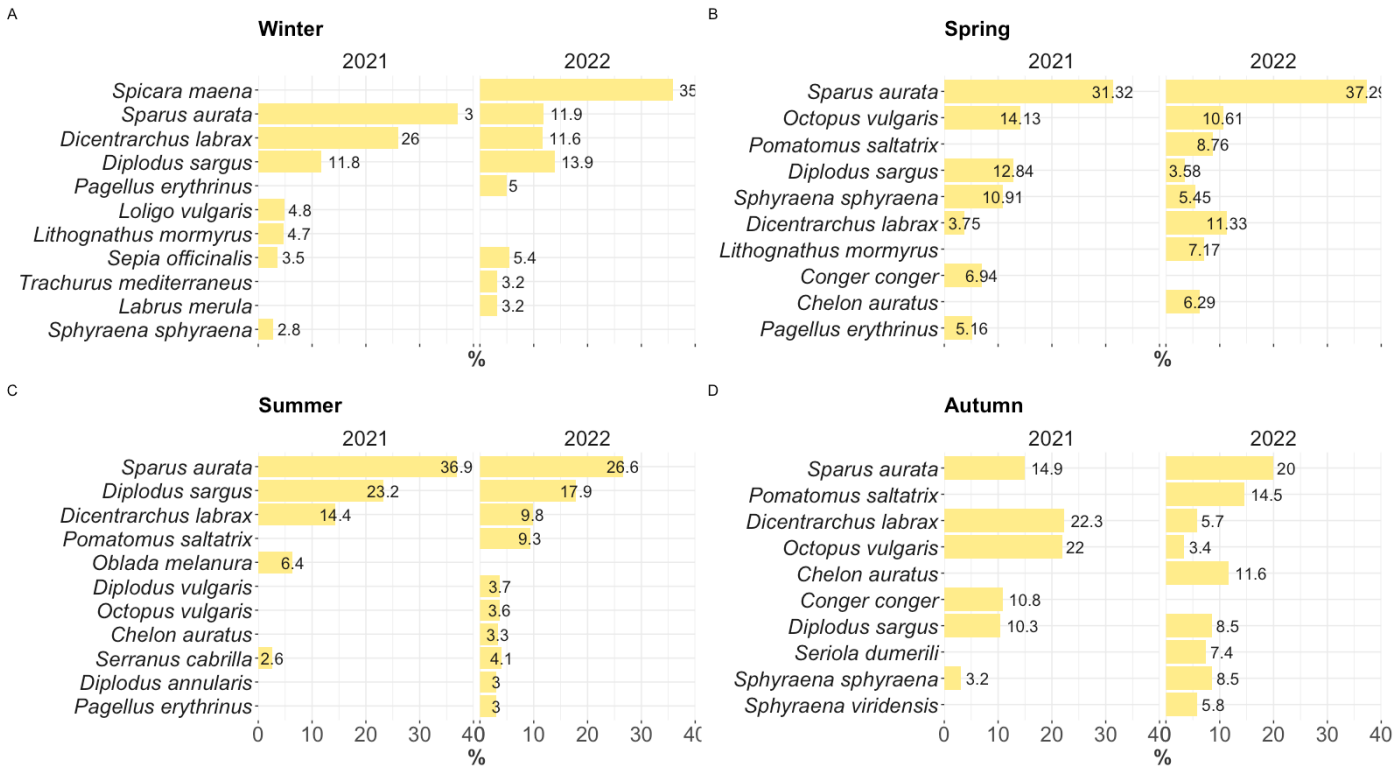

Figure 19: Catch composition (in weight %) by shore angling in winter (A), in spring (B), in summer (C) and in autumn (D) in 2021 (left) and 2022 (right).

5.1.5. Total annual catch

Estimates of total annual catches used catch data from the onsite surveys and effort values from the online surveys and were estimated first for each avidity class within each season, after which they were added into seasonal total catch values for the whole modality. The total catch of the species in 2021 was *Sparus aurata* (58 080 kg), *Dicentrarchus labrax* (30 137 kg), *Diplodus sargus* (28 189 kg), *Octopus vulgaris* (22 891 kg) and *Shyraena shyraena* (11 489 kg; Figure 20). The role of *Octopus vulgaris* in the shore angling catches had

been previously documented (ICATMAR, 2022), and should be observed carefully during the subsequent MRF monitoring programs in Catalonia. Also, following from the previous section's comments on *Conger conger*, caution is recommended in the use of the congrid's total catch results, as its identified potential overrepresentation in the onsite surveys could cause the extrapolation of the total catches to grossly overestimate its total catch. Similarly, other unidentified survey biases could potentially be influencing the rest of the results.

In 2022, the top species was the same, i.e. Sparus aurata (83 870 kg). However, other abundantly caught species were, in order of total annual catches, *Diplodus sargus* (31 006 kg), *Dicentrarchus labrax* (29 503 kg), *Pomatomus saltratix*, (29 301 kg), and *Chelon auratus* (19 115 kg; Figure 21).

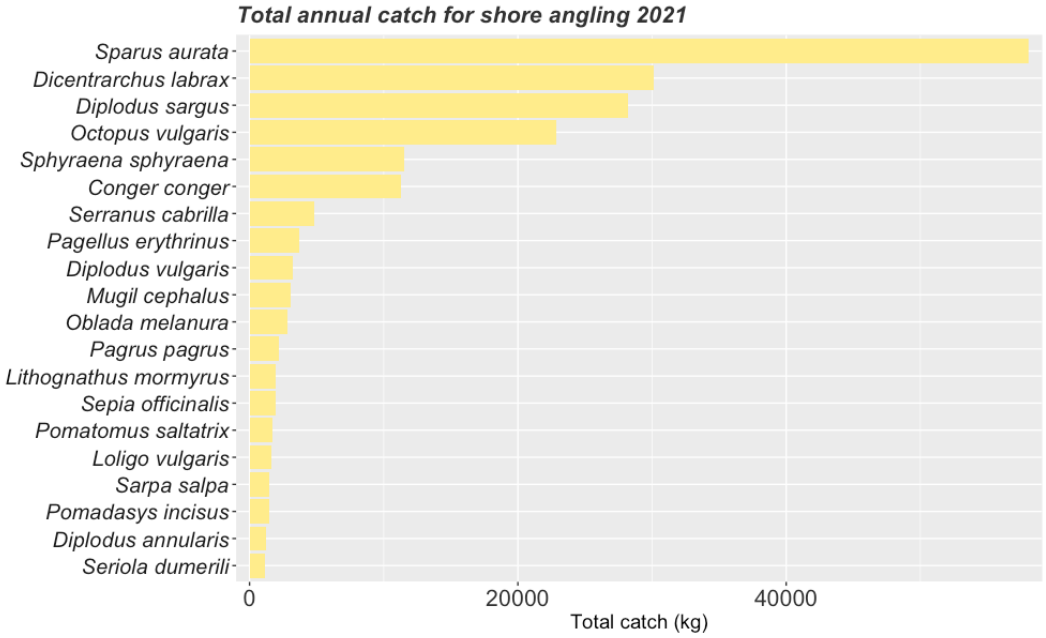

Figure 20: The total annual catch per species for shore angling in 2021. Only species with a relative weight above 1% of the total catch are shown. The graph shows 98% of the total catch.

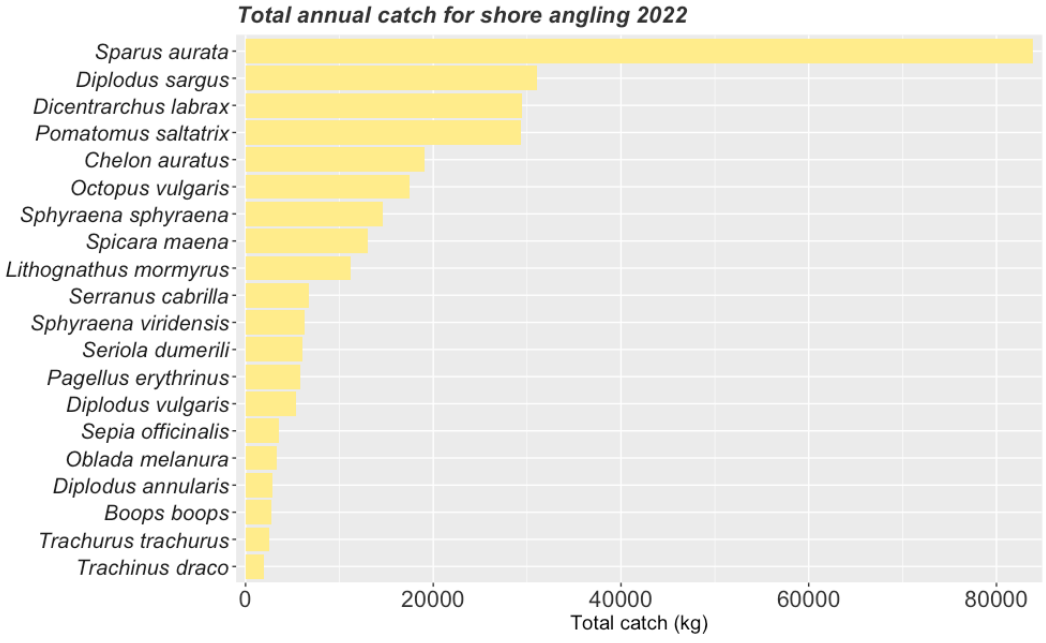

Figure 21: The total annual catch per species for shore angling in 2022. Only species with a relative weight above 1% of the total catch are shown. The graph shows 98% of the total catch.

When analyzing the catch by number of individuals instead of mass, the species mostly caught in 2021 were 34 333 individuals of *Sparus aurata*, 25 867 individuals of *Diplodus sargus*, and 21 635 individuals of *Serranus cabrilla* (Figure 22).

Similarly, the species mostly caught in 2022 were 65 048 individuals of *Spicara maena*, 38.263 individuals of *Sparus aurata*, and 24 871 individuals of *Diplodus sargus* (Figure 23). In the case of *Spicara maena*, we can have two scenes; a one-off case of such a catch in the winter of 2022 (see Annex V) or that it is a pattern that repeats itself more or less, every winter. In any case, it is important to be able to have a sequence of historical data to detect these usual or unusual peaks.

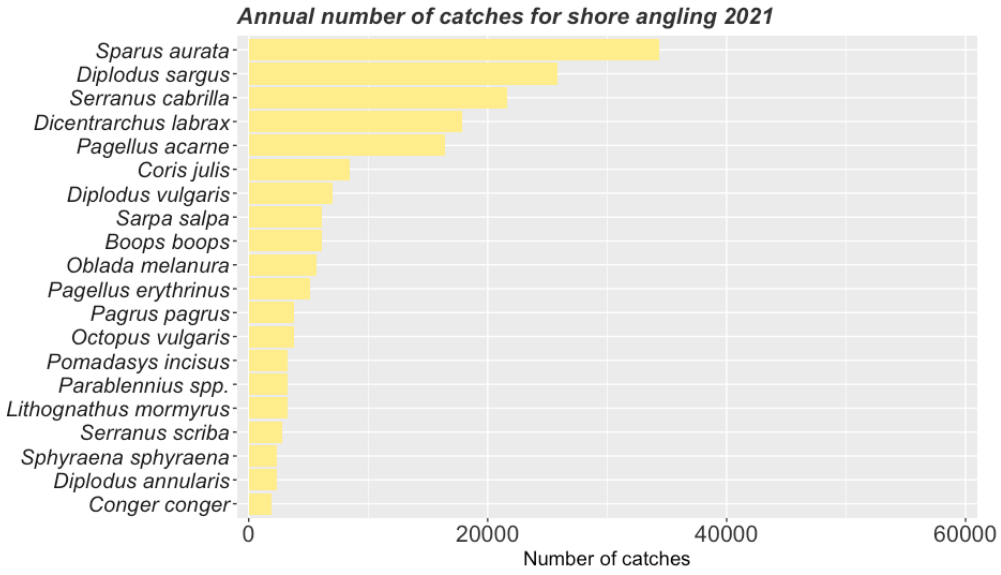

Figure 22: Estimation the total annual catch number per species for shore angling in 2021. Included catch and release and discards.

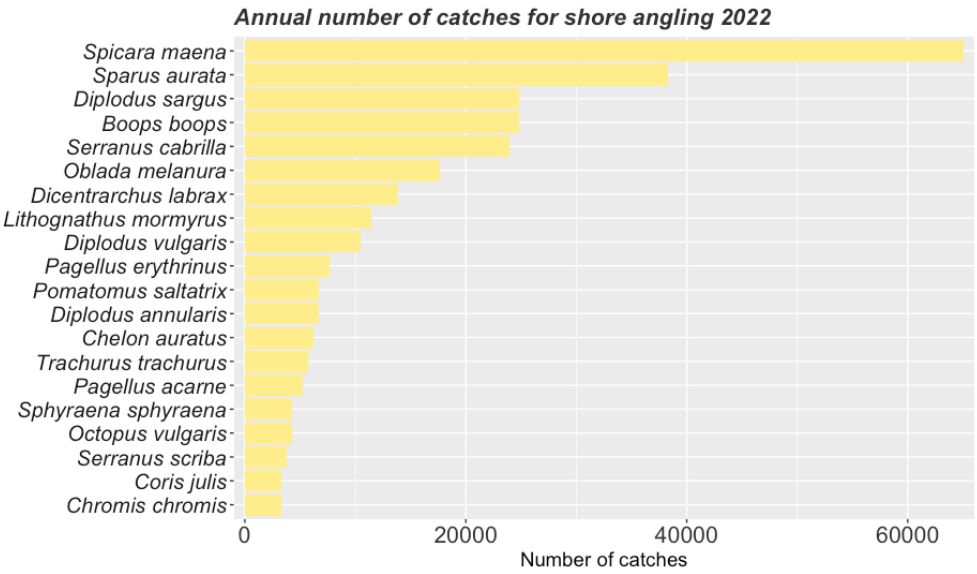

Figure 23: Estimation the total annual catch number per species for shore angling in 2022. Included catch and release and discards.

5.1.6. Distribution of the total annual catch

The zones with more catches are very similar between both studied years. However, in 2022, there are more annual catches, in general, compared to 2021. The spatial distribution of the annual catches evidences the ranging fishing impacts (Figure 24). In general, the most populated areas such as Barcelona and it is adjacent zones yield the highest amount of catches on a per kilometre basis. Population density and fishing extraction are particularly related in the case of shore angling.

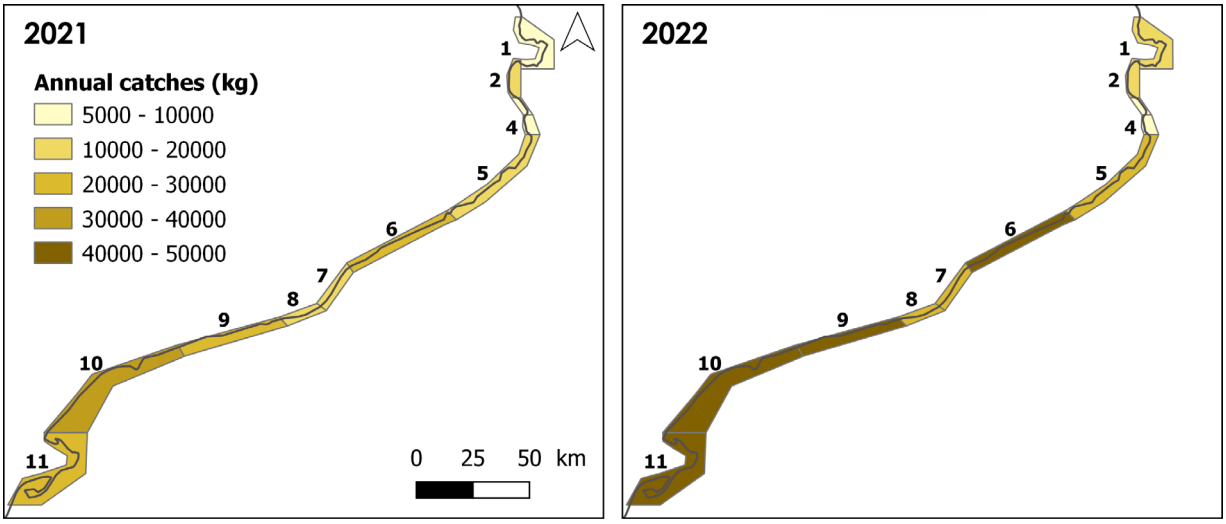

Figure 24: Distribution of total annual catch by shore angling in 2021 (left) and 2022 (right).

5.1.7. Inequality in the distribution of the total annual catches

Shore recreational anglers are very heterogeneous in their fishing characteristics. They present a diverse range of avidity habits and practice a number of fishing techniques (see ICATMAR, 2021) that combine with experience and fishing motivations to influence fishing effort, fishing yields, and total catches. The different avidity groups designed in this study (see section 4) are responsible for very different proportions of the total catches. Below are the figures corresponding to shore angling modality in 2021 and 2022, where the number of anglers in each avidity class is directly associated with their relative contributions to the total modality catch. Relative individual impacts vary enormously in relation to their avidity patterns. These amount to massive differences in the aggregate impact of each avidity class. It must be considered that the values presented are the product of estimations based on extrapolations that, although consistent with the avidity class model are not based on direct observations, and should therefore be observed with caution.

For shore angling, over 73% of the anglers took less than 20 fishing trips during the 2021 period, jointly contributing 26% of the total modality catch. The remaining 19% who fished more than 20 days per year, of which 8% took over 50 trips, caught just under 74% of the total shore fishing catch. These enormous inequalities in the relative contributions to the total catch are explained by the positive synergy between avidity and catch rates. This results in the stark observed differences in annual catch extractions between avidity classes. While sporadic avidity anglers caught on average a mere 0.16 kg, the low avidity recreational anglers extracted approximately 4 kg biomass during the one-year period. Conversely, medium avid class anglers extracted almost 8 kg per year, and the most avid anglers extracted a median of 40 kg throughout 2021 (Figure 25).

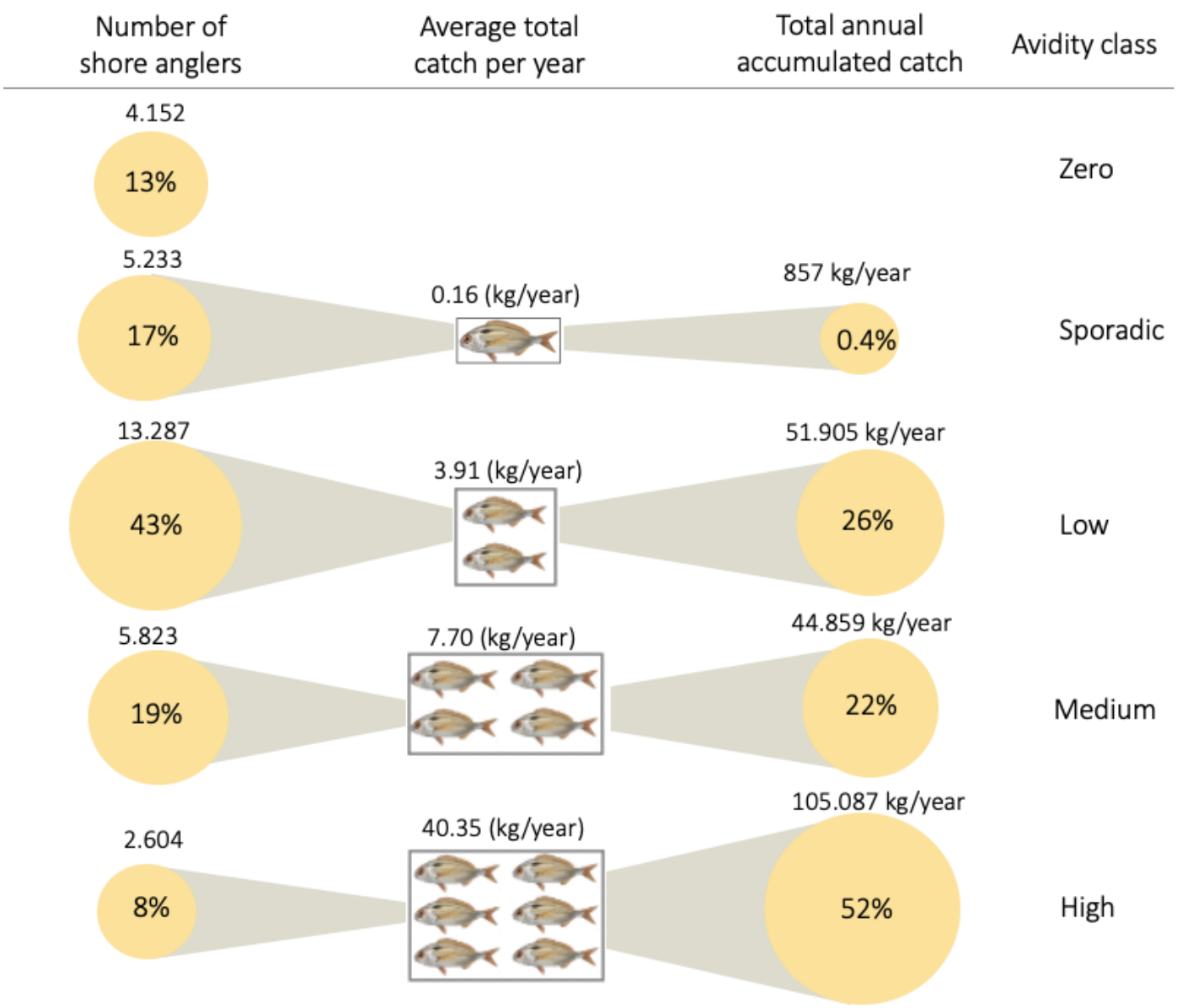

Figure 25: Number and proportion of shore angling, mean individual fishing intensity, and total accumulated catch per avidity group during 2021.

In 2022, over 71% of the shore anglers took less than 20 fishing trips during the 2022 period, jointly contributing 19% of the total modality catch. The remaining 19% who fished more than 20 days per year, of which 10% took over 50 trips, caught just under 81% of the total boat fishing catch. As a result, while sporadic avidity anglers caught on average a mere 0.19 kg, the low avidity recreational anglers extracted approximately 4 kg biomass during the one-year period. Conversely, medium avid class anglers extracted almost 11 kg per year, and the most avid anglers extracted a median of 59 kg throughout 2022 (Figure 26).

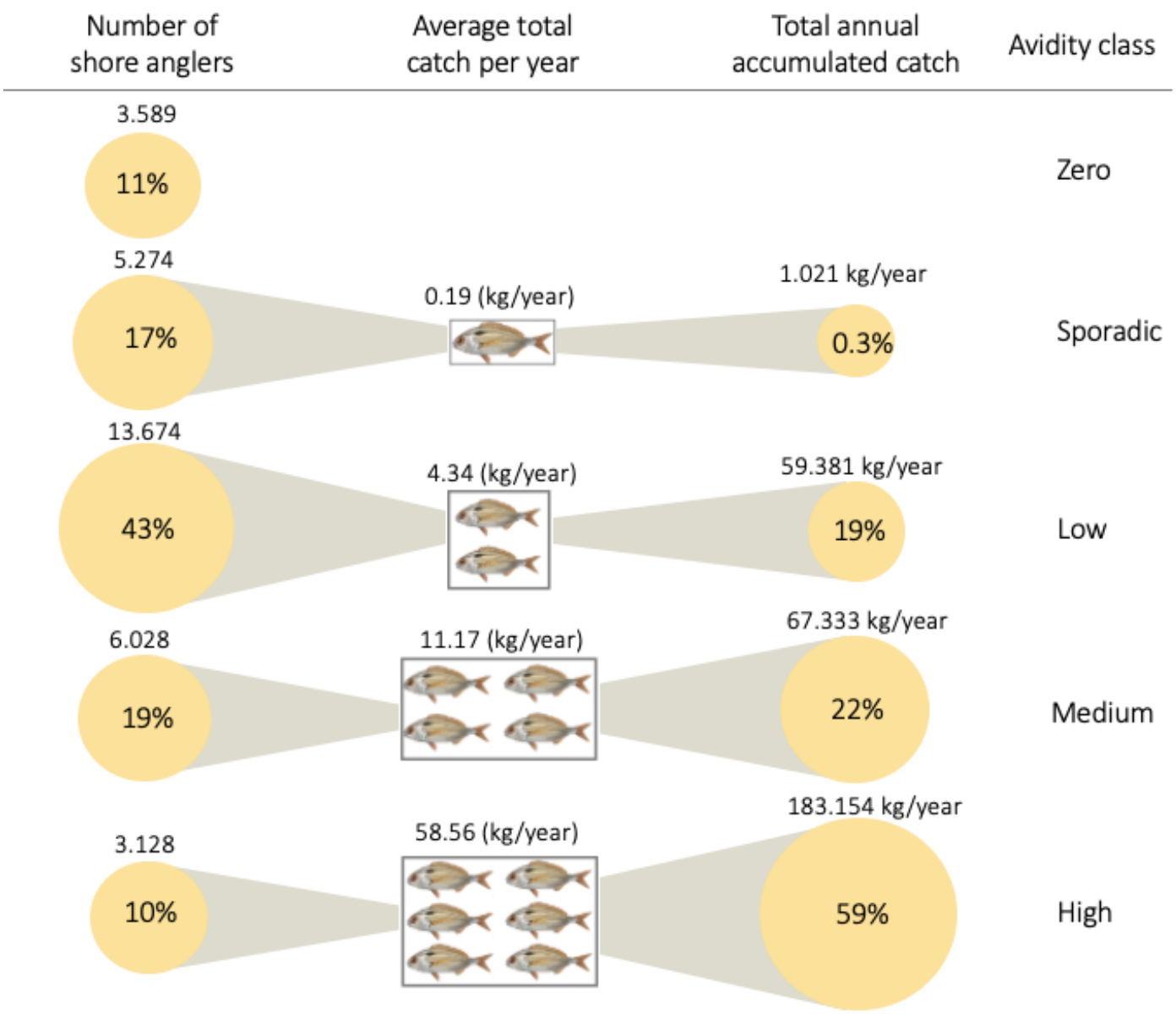

Figure 26: Number and proportion of shore angling, mean individual fishing intensity, and total accumulated catch per avidity group during 2022.

Boat angling

5.2. Boat angling

5.2.1. Fishing effort

The results of the boat angling effort were based on annual effort distributions from the online surveys, which allowed to classify respondents into avidity classes based on their declared fishing effort during the past 12 months (Table 6). Because the online survey only represents license-holders. Therefore, the effort distribu-

Table 6. Avidity class distribution of licensed boat recreational anglers

	2021	2022
Zero	10%	8%
Sporadic (1 -2 days)	3%	3%
Low (3 -19 days)	40%	37%
Medium (20 -49 days)	32%	34%
High (+50 days)	16%	19%

tions from the online surveys were extrapolated only to licensed fishers.

The results showed a slightly lower proportion of individuals holding a recreational fishing license that did not make use of it during 2021 and 2022 in which their marine recreational fisher license was active (10% in 2021 and 8% in 2022; Table 7). For the sporadic avidity class, the percentage was the same (3%; Table X). For the two years, most anglers showed low avidity effort pattern (40% and 37% in 2021 and 2022, respectively). Boat anglers with medium avidity class were similar between years (32% and 34% in 2021 and 2022, respectively). Altogether, between 16% and 19% of boat recreational anglers were highly avid.

The responses of the percentages obtained from the surveys were extrapolated to the number of active fishers to estimate the number of anglers by avidity category. The year-to-year variation was very small around 13% (Table 7).

Taula 7. Estimate total number of boat anglers of each years.

	2021	2022	Variation	% variation
Zero	844	735	109	-12.9
Sporadic (1 -2 days)	1 339	1 621	282	21.1
Low (3 -19 days)	4 001	4 451	450	11.2
Medium (20 -49 days)	2 777	3 164	387	13.9
High (+50 days)	1 406	1 755	349	24.8
Total	**10 367**	**11 722**	**1 355**	**13.1**

Reported annual fishing effort for boat anglers who went fishing at least once during 2021 showed an average of 25 fishing days per year, with a similar periodicity through the different seasons, ranging from 27 days per year in spring to 25 days per year in summer and winter, each season. Similarly, reported annual fishing effort for shore anglers who went fishing at least once during 2022 showed an average of 28 fishing days per year, also with a similar periodicity through the different seasons ranging from 29 days per year in spring and autumn, each season, to 26 days per year in summer.

However, in order to really know the frequency of fishing days, it was analysed using the monthly average by avidity class per season in 2021 and in 2022 (Table 8).

There is a similar tendency for both years, with the highest average obtained from the high avidity class, and it diminishes as the class progresses towards the sporadic category.

Table 8. Monthly average from 1 month for analysed through online surveys by answering the question: *How many times have you gone fishing in the last 4 weeks?*

Year 2021	Zero	Sporadic	Low	Medium	High
Winter	0	0.03±(0.26)	0. 27±(0.78)	0.90±(1.64)	7.34±(6.75)
Spring	0	0.09±(0.66)	0.94±(1.33)	2.23±(2.27)	7.80±(4.66)
Summer	0	0.18±(0.95)	1.87±(2.43)	4.12±(3.47)	8.84±(4.83)
Autumn	0	0.07±(0.58)	0.74±(1.51)	2.54±(2.33)	7.65±(5.43)
Year 2022	**Zero**	**Sporadic**	**Low**	**Medium**	**High**
Winter	0	0.06±(0.44)	0,71±(1.53)	1.67±(2.15)	7.27±(5.40)
Spring	0	0.09±(0.52)	0,94±(3.07)	1.86±(2.39)	9.03±(5.89)
Summer	0	0.14±(0.78)	1,51±(1.84)	4.31±(4.43)	9.11±(5.28)
Autumn	0	0.06±(0.38)	0,65±(1.28)	2.97±(3.07)	9.48±(5.99)

5.2.1.1. Effort distribution

The areas where most fishing days are spent in 2021 are Delta de l'Ebre, Costa Daurada and the south of Costa Brava, followed, by Costes del Garraf, Maresme and Cap de Creus (Figure 27), portraying a very similar spatial distribution as that found for shore angling. In most areas, the season when most people go fishing is in summer, with 94 751 fishing days. Most boat angling trips were taken in the central and southern zones of the Catalan coastline. Approximately 39 to 41% of the boat fishing activity was spent in the northern zones of the Catalan coast. In detail, the northern zone of Cap de Creus and Costa Brava are the most intensively fished per kilometre (Figure 27). In summer, this activity increases as the population raises with the presence of tourists. Overall, the boat angling effort is estimated in 262 256 fishing trips per year.

The average daily boat angling trips per kilometre show the degree to which fishing activity is unevenly distributed at a temporal and geographical scales (Figure 28; Annex II). Boat fishing intensity in the Barcelona area was the highest throughout the seasons, with a yearly average of 3.3 fishing trips per kilometre (Figure 28). There was seasonal variability in Delta de l'Ebre, Costa Daurada, Cap de Creus and Costa Brava zones, which activity was reduced during the colder seasons.

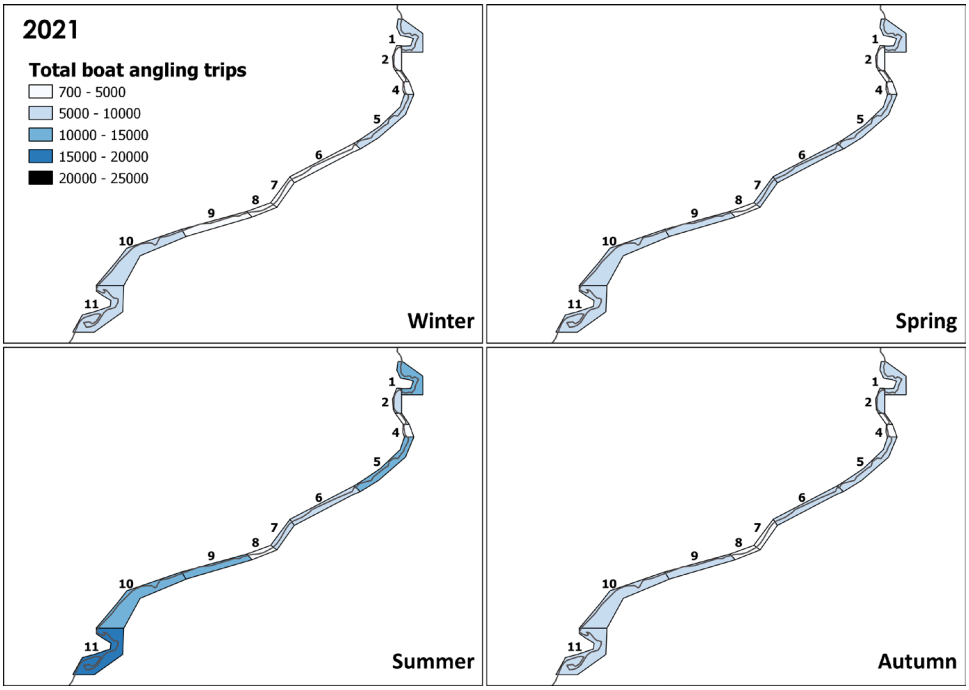

Figure 27. Total boat fishing trips during 2021 per zone during each season. In this analysis we do not take into account areas where fishing is not allowed.

Following the same analytical pattern, the areas with most fishing days were Delta de l'Ebre, the south of Costa Brava and Costa Daurada, followed by Cap de Creus, Costes del Garraf and Maresme (Figure 29), portraying a very similar spatial distribution as that found for shore angling. In most areas, the season when most people went fishing was summer, with abound 109 748 fishing days. Most boat angling trips were taken in the central and southern zones of the Catalan coastline (40% in the north of Catalonia and 60% the rest). Overall, the boat angling effort accumulated an estimate of 338 804 fishing trips per year.

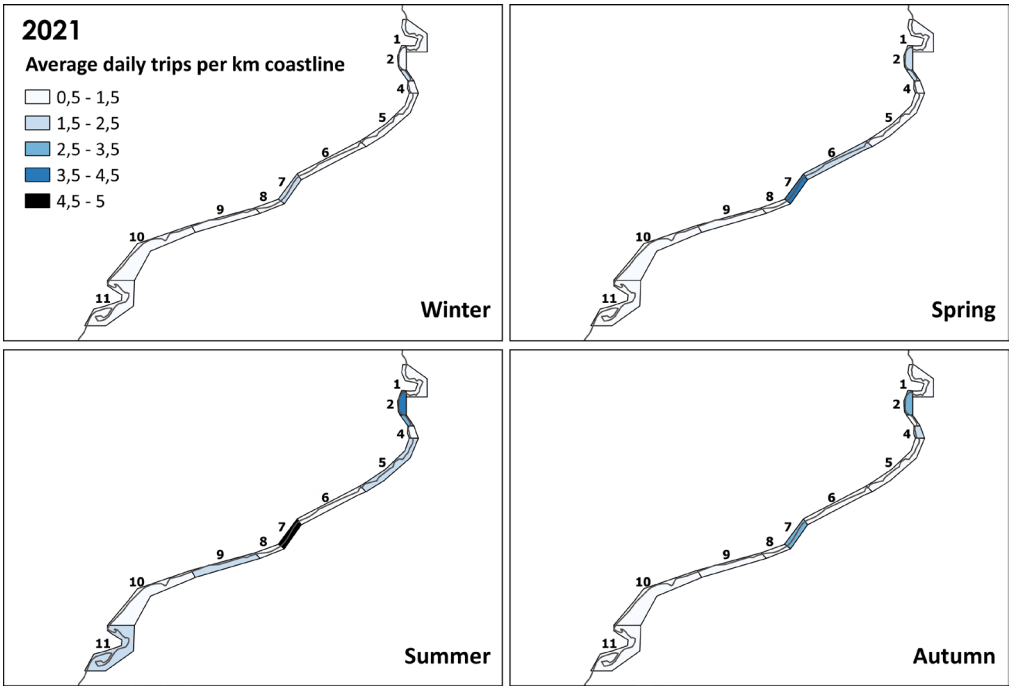

Figure 28: Average number of daily fishing trips during 2021 per kilometer coastline within each season.

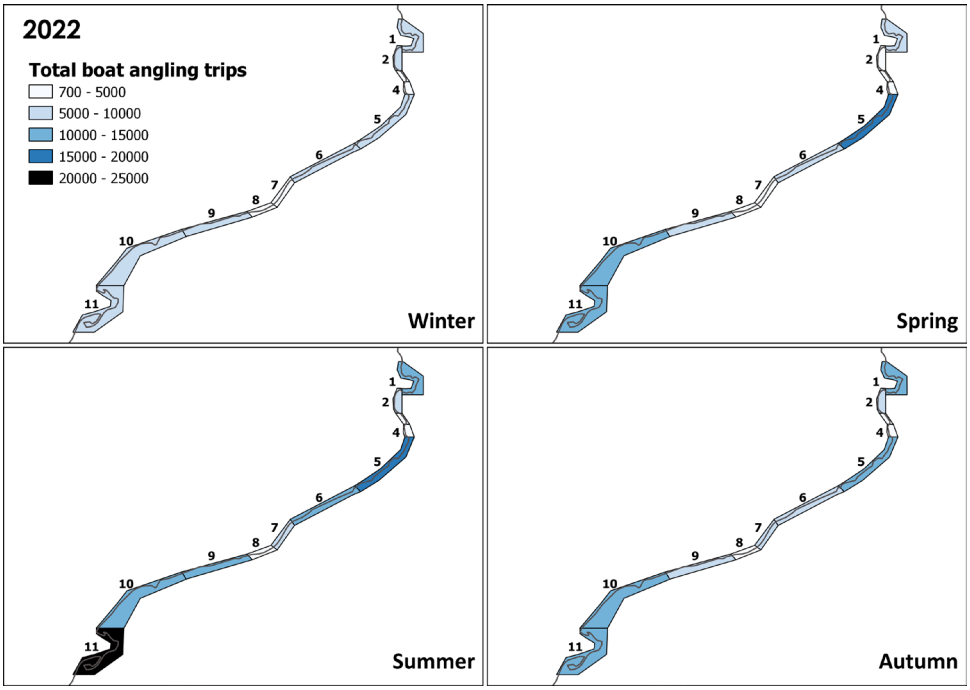

Figure 29. Total boat fishing trips during 2022 per zone during each season. In this analysis we do not take into account areas where fishing is not allowed.

The average daily boat angling trips per kilometre in 2022 show the degree to which fishing activity is unevenly distributed at a temporal and geographical level (Figure 30; Annex II). Boat fishing intensity in the Barcelona area was the highest throughout the seasons, with a yearly average of 3.2 fishing trips per kilometre, followed by Golf de Roses, with a yearly average of 2.9 fishing trips per kilometre (see below Figure 30). There was seasonal variability in Costa Daurada, Costa Brava and the Barcelona zones, which have a very reduced activity during the colder seasons. Conversely, boat fishing intensity was notably stable in the zones of Montgrí Coast and Golf de Roses.

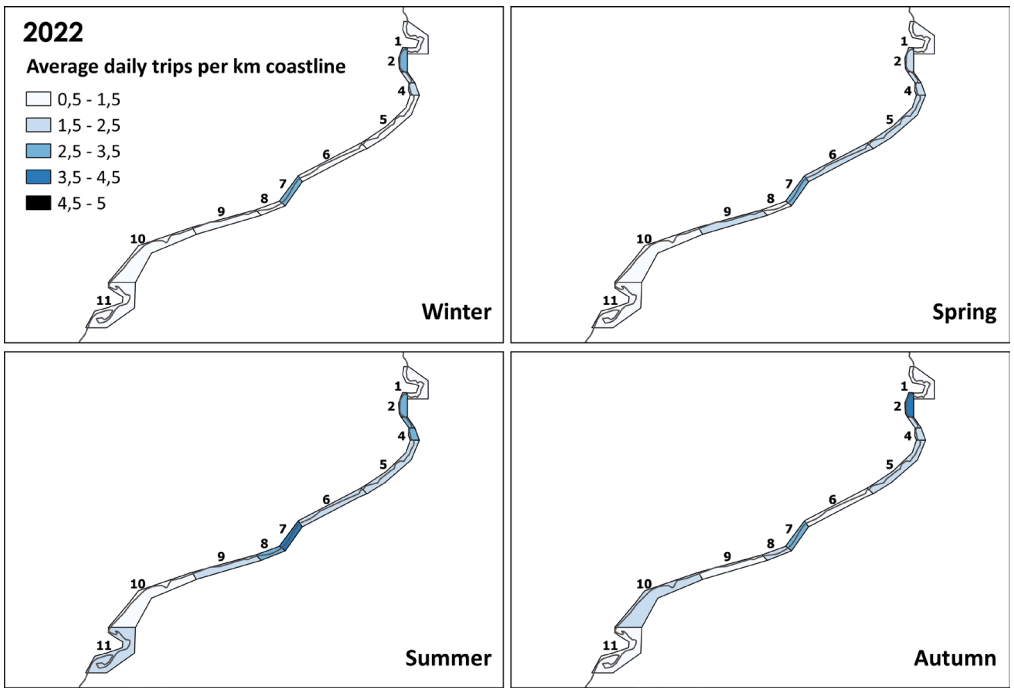

Figure 30: Average number of daily fishing trips during 2022 per kilometer coastline within each season.

5.2.2. Fishing yield

The fishing yield was analysed using catch per unit effort (CPUE) measured in kilograms caught per day fished. Comparing the two years studied we see that there was a non-significant difference (p-value=0.191) using a Wilcoxon rank with continuity correction. The average CPUE for boat anglers was very similar for both years studied (0.71±1.24 kg/day and 1.07±2.09 kg/day in 2021 and 2022, respectively), as detailed in Figure 31.

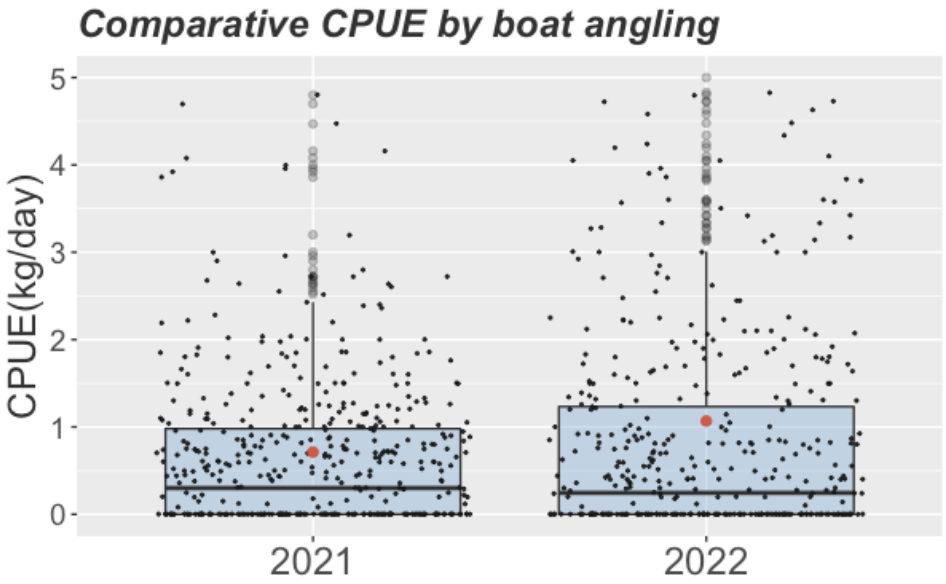

Figure 31: CPUE by 2021 and 2022 for boat angling. The red rot indicates the mean, the horizontal black line represents the median the boxes represent the interquartile ranges (25 – 75%) and the vertical line represents the 90% spread of the data.

Seasonally, there were significant differences (p-value<0.05) in CPUE for boat angling fishing between spring - winter, spring – summer, autumn – summer and autumn – winter in 2021. In detail, the average CPUE from spring was the highest (1.05±1.90), and significantly differed (p<0.01) from all other seasons. Moreover, autumn (0.92±0.98) was different (p<0.01) than summer (0.44±0.59) and winter (0.54±1.17; Figure 32).

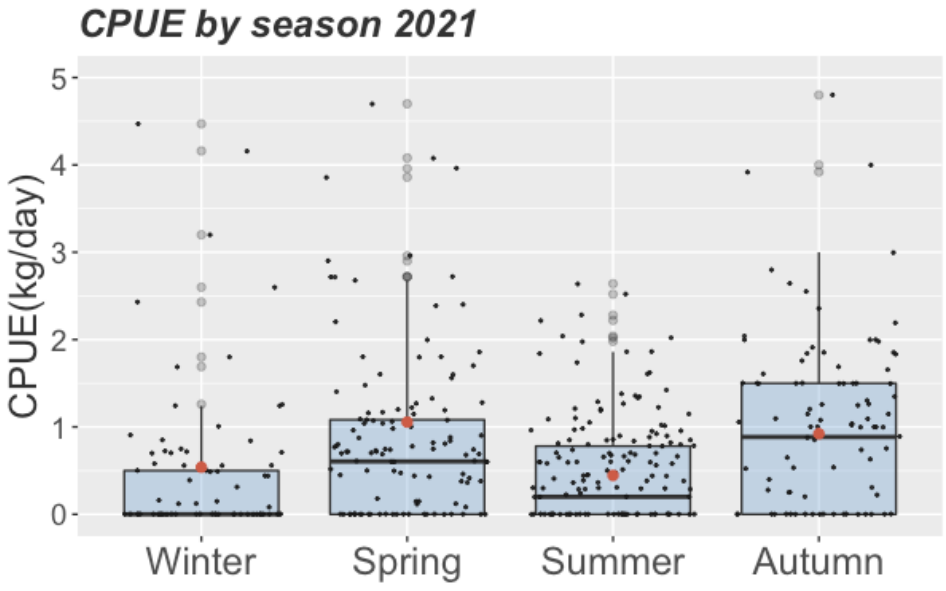

Figure 32: CPUE by season in 2021 for boat angling. The red rot indicates the mean, the horizontal black line represents the median the boxes represent the interquartile ranges (25 – 75%) and the vertical line represents the 90% spread of the data.

Similarly, there were significant differences (p-value=0.014) in CPUE for boat angling fishing among seasons in 2022. In detail, winter had the lowest average CPUE (0.55±0.87), which was significantly different than summer (1.11±2.58; p-value=0.0497) and autumn (1.54±2.19; p<0.01). Spring (0.80±1.30) was also significantly different than summer (p=0.0373) and autumn (p=0.001) but there were no differences between winter and spring (p-value=0.77; Figure 33).

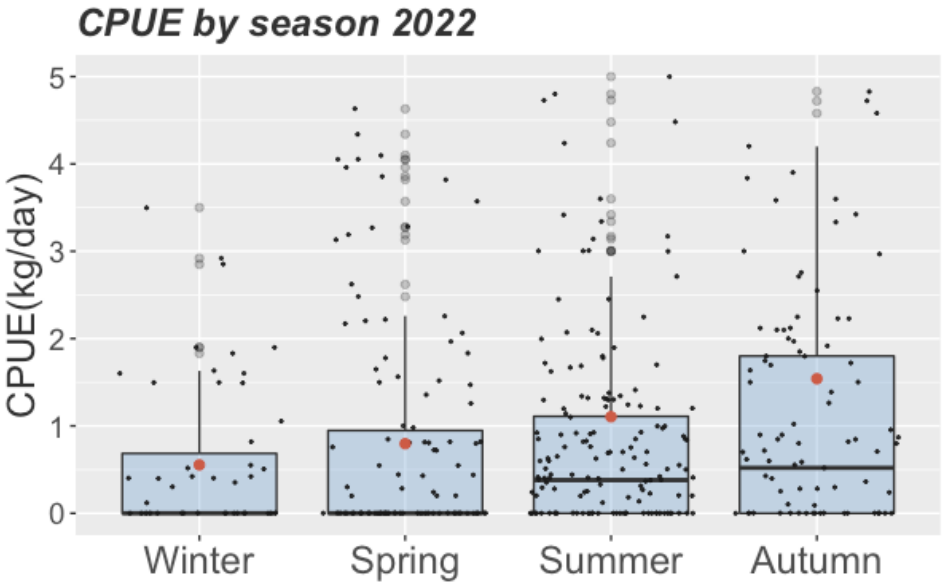

Figure 33: CPUE by season in 2021 for boat angling. The red rot indicates the mean, the horizontal black line represents the median the boxes represent the interquartile ranges (25 – 75%) and the vertical line represents the 90% spread of the data.

5.2.3. Intended target species

Recreational fishers mostly have a specific catch or set of catches in which they are interested. It must be considered the intended target species are merely a declaration of intentions, and do not necessarily reflect the eventual outcome of a fishing trip, but they can be considered an important motivation axis setting the expectations for a given fishing trip.

Fishing by boat allows for more mobility than other modalities, giving boat fishers greater access to a range of fishing environments. Besides, the different fishing techniques available to boat fishers allow accessing species of varying characteristics. In 2021, boat anglers from the Catalan coast aimed to catch the most popular species group, the *Sparidae* family was led *Dentex dentex*. Still, *Dicentrarchus labrax* was the overall most coveted catch for boat. Also, in this modality, the target catches for cephalopods generated an especially high interest, specially the *Loligo vulgaris*. Another feature of this modality is catching big pelagic fish such as tuna (*T. thynnus* or *T. alalunga*), and other great pelagic species such as *Sarda sarda* and *Coryphaena hippurus*. It is worth mentioning that due to specific fishery regulations for tuna, these species only can catch and released. Other smaller pelagic fish catches of interest include such as *Trachurus trachurus* and *Scomber scombrus*.

The intended target species' answers from 2022 are very similar to that from 2021 (Figure 34).

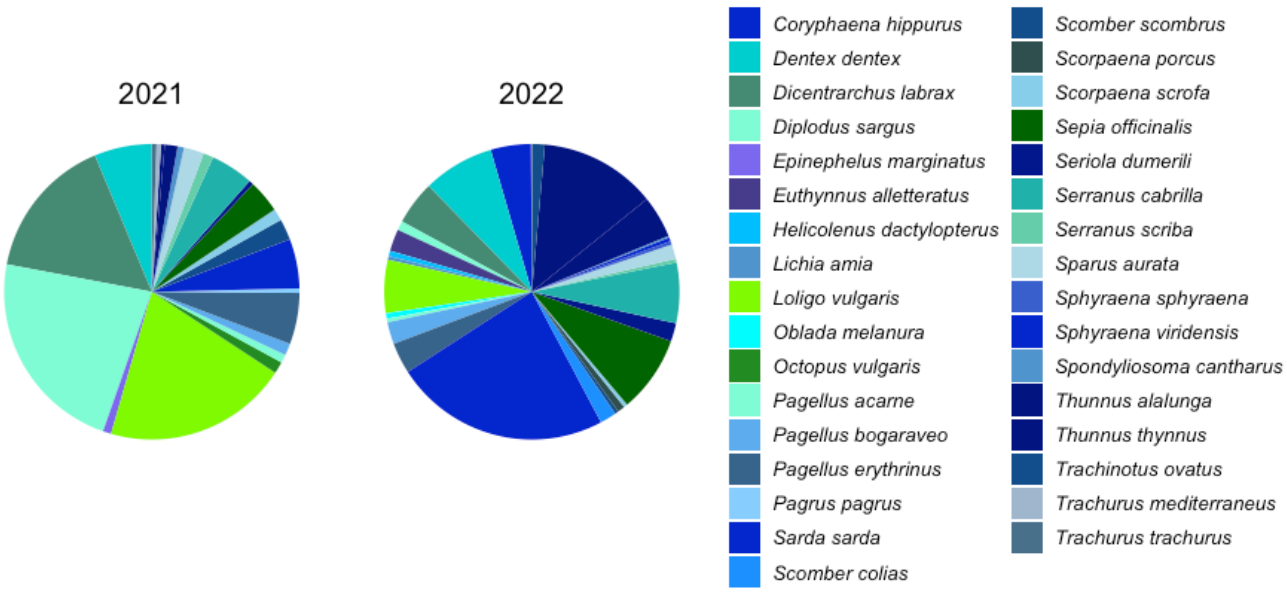

Figure 34: Percentage of spices according to declared as target by boat angling in 2021 and 2022.

5.2.4. Seasonal catch composition

In the onsite sampling, a total 1 041 individual catches from boat fishing were identified from a total 51 different species during the studied years. Catch composition results show the actual catch estimates obtained from the onsite surveys. They contrast with results from target species, and it is clear that for all three fishing modalities, there is a difference between species' desirability and their actual catchability. Species' catch seasonality may also be observed, as different species are more or less available, or more or less desired during different times of the year.

Catch diversity patterns for boat fishing coincided with those of shore angling, with higher diversity values obtained in spring (32 different species observed), followed by summer with 30, then autumn with 13 and the lowest values are found in winter with 12 out of a total of 44 different species observed for boat angling. Although the total number of different species observed for boat angling and shore angling was the same, it is worth remarking that the total number of boat angling surveys was much lower (780 for shore angling and 554 for boat angling), and it could be argued that boat angling diversity would surpass that of shore angling if the same number of observations was attained. Increased in 2022, summer was found to be the season with the highest biodiversity, with 38 different species observations (Annex V, Figure 75C; note that only species with over 1% of the total catch are represented), followed by spring with 21, then autumn with 19 and finally, the lowest values are found in winter with 14 out of a total of 47 different species observed for boat angling.

There were some similarities and differences among seasons between both studied years. In winter, the two main species were the same for both studied years, *L. vulgaris* and *Dentex dentex*. However, other important species caught in 2021 (i.e., *Pomatomus saltatrix* and *Seriola durmerili*) were absent in 2022. In spring, there was a great difference between the top caught species according to year being *S. durmerili* (15.6%) and *D. dentex* (15.1%) the main catches in 2021 but *Sepia officinalis* (51.4%) in 2022. Summer also showed great differences according to year. In 2021, the catch was equally dominated by *P. erythrinus*, *S. scombrus* and *Euthynnus alletteratus* (9.8%, 9.3%, 9.2%, respectively) whereas in 2022, the dominant species were *T. alalunga* (30.5%) and *E. alletteratus* (18.4%). In autumn, more than half of the catch was composed by a single species but they varied according to year. While in 2021 *L. vulgaris* was dominant (56.0%), in 2022 *E. alletteratus* represented the 51.3% of the catch (Figure 35).

Figure 35: Catch composition (in weight %) by boat angling in winter (A), in spring (B), in summer (C) and in autumn (D) in 2021 (left) and 2022 (right).

5.2.5. Total annual catch

The main catch of the boat angling in 2021 was *Loligo vulgaris* with 43 387 kg caught annually, followed by *Dentex dentex* with 27 176 kg, and S. *dumerili* with 24 303 kg (Figure 36). The previous section showed how seasonality patterns are highly influential on species catches, but it is also worth noting the great variety of different fishing techniques of this modality. It is worth noting that the results here presented are the product of a survey design that has made its best effort to capture the variety of techniques, seasonal and geographical patterns, but that nonetheless, specific practices may be over or underrepresented in the surveys causing cascading effects onto the total catch per species results. Particularly vulnerable activities to temporal sources of bias are the catches of the cephalopods *Loligo vulgaris* and *Sepia officinalis*, as well as *Xyrichtys novacula*. Moreover, sampling difficulties such as caution or unwillingness to declare part of the

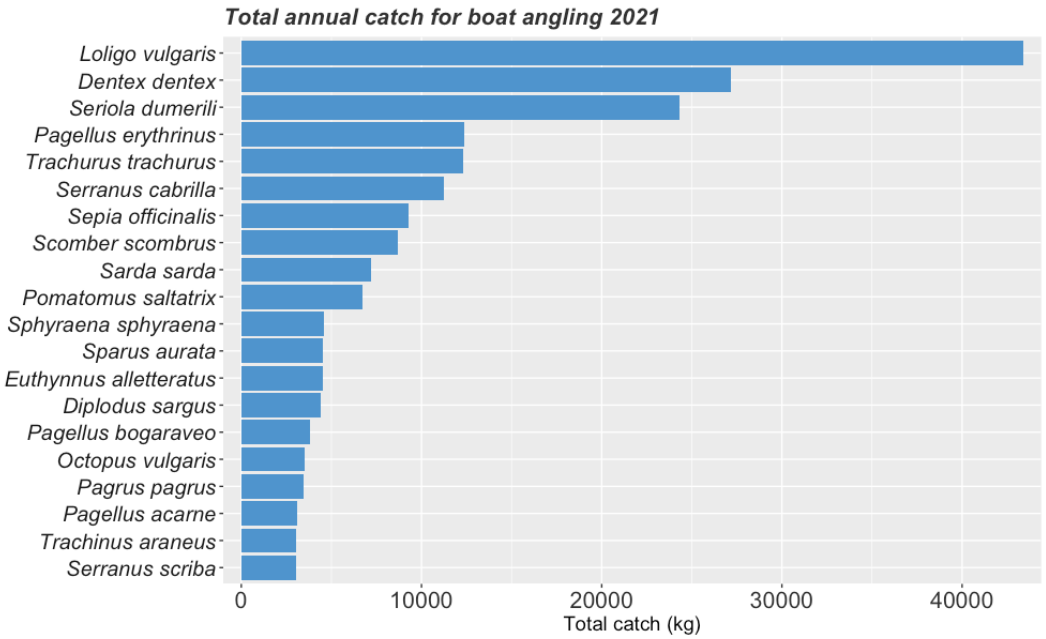

Figure 36: The total annual catch per species for boat angling in 2021. Only species with a relative weight above 1% of the total catch are shown. The graph shows 98% of the total catch.

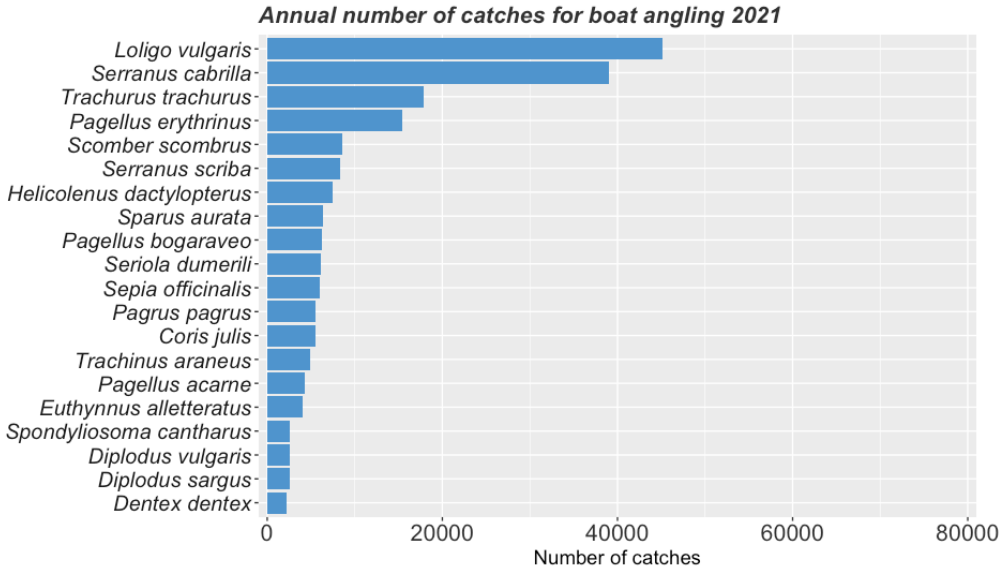

Figure 37: Estimation total annual catch number per species for boat angling in 2021. Included catch and release and discards.

catches could have an influence on results, potentially underrepresenting big pelagic catches. It is likely that the onsite sampling method is only adequate to observe legal fishing practices, as the surveyors have no inspection authority. This supposition could be applied for all three fishing modalities but maybe especially relevant for the surveys conducted in ports, as they require fishers to actively disembark the catch from the boat for the surveyors to observe. Some of the marine resource extractions may therefore remain ignored by our surveyors, and this could potentially have effects of an unknown magnitude on the total catch volumes per species here presented.

When analyzing the catch by number of individuals instead of mass, the species mostly caught in 2021 were 45 100 individuals of *L. vulgaris*, 38 995 individuals of *S. cabrilla*, and 17 816 individuals of *T. trachurus* (Figure 37). Despite that in mass, *D. dentex* is one of the most important species, in number of individuals only represents 2 243 fish.

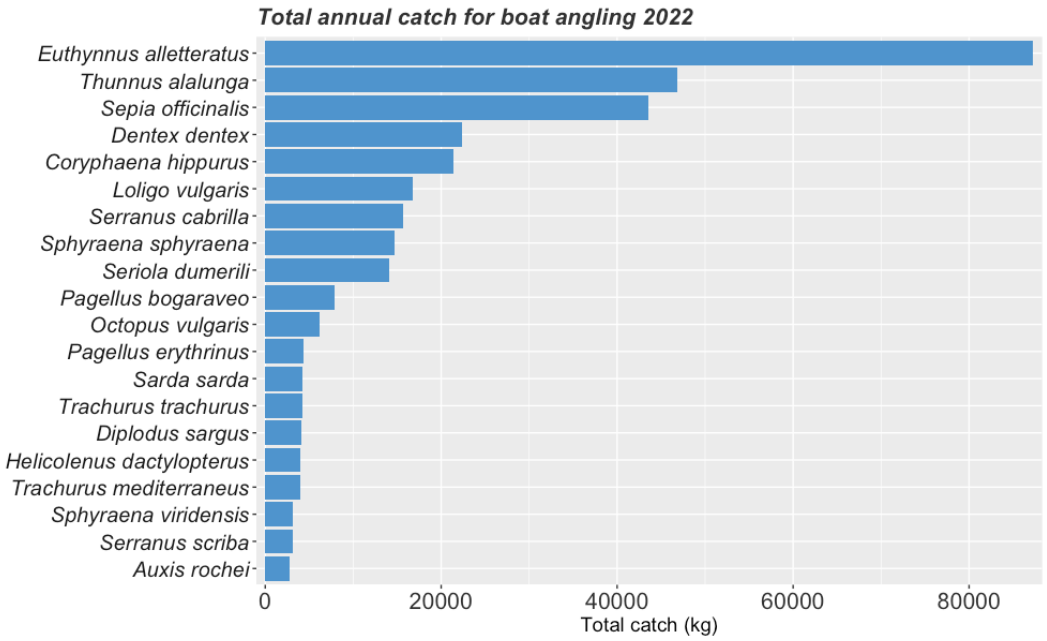

Figure 38: The total annual catch per species for boat angling in 2022. Only species with a relative weight above 1% of the total catch are shown. The graph shows 98% of the total catch.

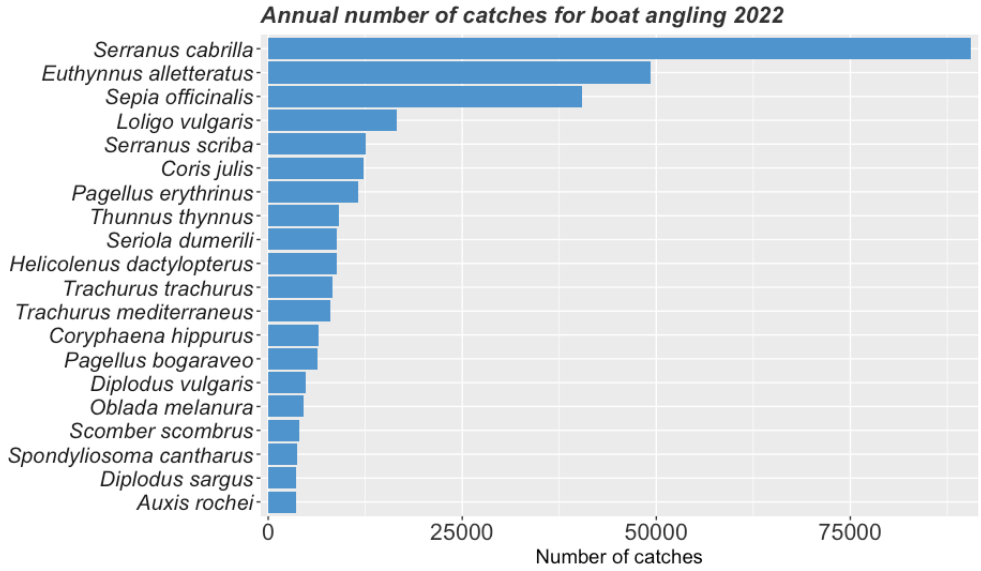

Figure 39: Estimation total annual catch number per species for boat angling in 2022. Included catch and release and discards.

In 2022, four of the top five species varied being *E. alletteratus* the most important in catches (87 308 kg). Other abundantly caught species were, in order of total annual catches, *T. alalunga* with 46 830 kg, followed by *S. officinalis* with 43 574 kg, followed by *D. dentex* with 23.378 kg, and *Coryphaena hippurus* with 21 381 kg annually. The only common species for both years in the top five caught species list is *D. dentex* (Figure 38).

The species mostly caught in 2022 varied from those in 2021. The common species found both years is *S. cabrilla*, with 90 519 individuals in 2022, but the next most abundant species for this year were *E. alletteratus* (49 283) and *S. officinalis* (40 482; Figure 39).

5.2.6. Distribution of the total annual catch

The zones with more and less catches are very similar between both studied years. However, in 2022, there are more annual catches, in general, compared to 2021. The zone where the annual catches increased were Delta de l'Ebre, Costa Daurada and Costa Brava (Figure 40).

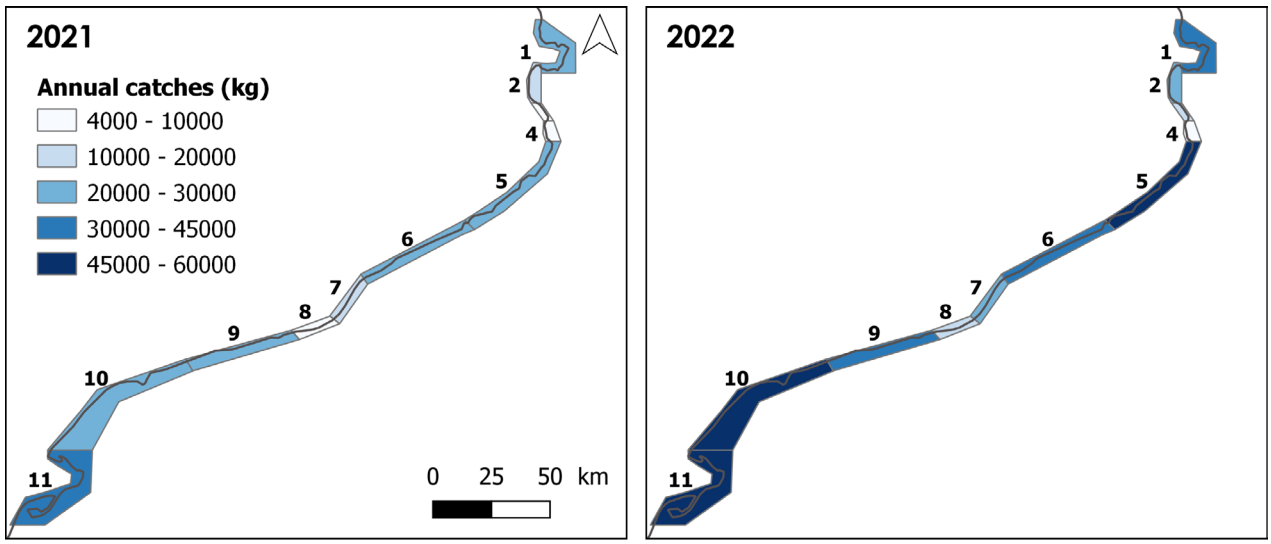

Figure 40: Distribution of total annual catch by boat angling in 2021 (left) and 2022 (right).

5.2.7. Inequality in the distribution of the total annual catches

Boat recreational anglers are very heterogeneous in their fishing characteristics. They present a diverse range of avidity habits and practice a number of fishing techniques that combine with experience and fishing motivations to influence fishing effort, fishing yields, and total catches. The different avidity groups designed in this study are responsible for very different proportions of the total catches. Below are the figures corresponding to boat angling modality in 2021 and 2022, where the number of anglers in each avidity class is directly associated with their relative contributions to the total modality catch. Relative individual impacts vary enormously in relation to their avidity patterns. These amount to massive differences in the aggregate impact of each avidity class. It must be considered that the values presented are the product of estimations based on extrapolations that, although consistent with the avidity class model are not based on direct observations, and should therefore be observed with caution.

For boat angling, over 60% of the anglers took less than 20 fishing trips during the 2021 period, jointly contributing 23% of the total modality catch. The remaining 27% who fished more than 20 days per year, of which 14% took over 50 trips, caught just under 77% of the total boat fishing catch. These enormous inequalities in the relative contributions to the total catch are explained by the positive synergy between avidity and catch rates. This results in the stark observed differences in annual catch extractions between avidity classes. While sporadic avidity anglers caught on average a mere 0.16 kg, the low avidity recreational anglers extracted approximately 12 kg biomass during the one-year period. Conversely, medium avid class anglers extracted almost 20 kg per year, and the most avid anglers extracted a median of 80 kg throughout 2021 (Figure 41).

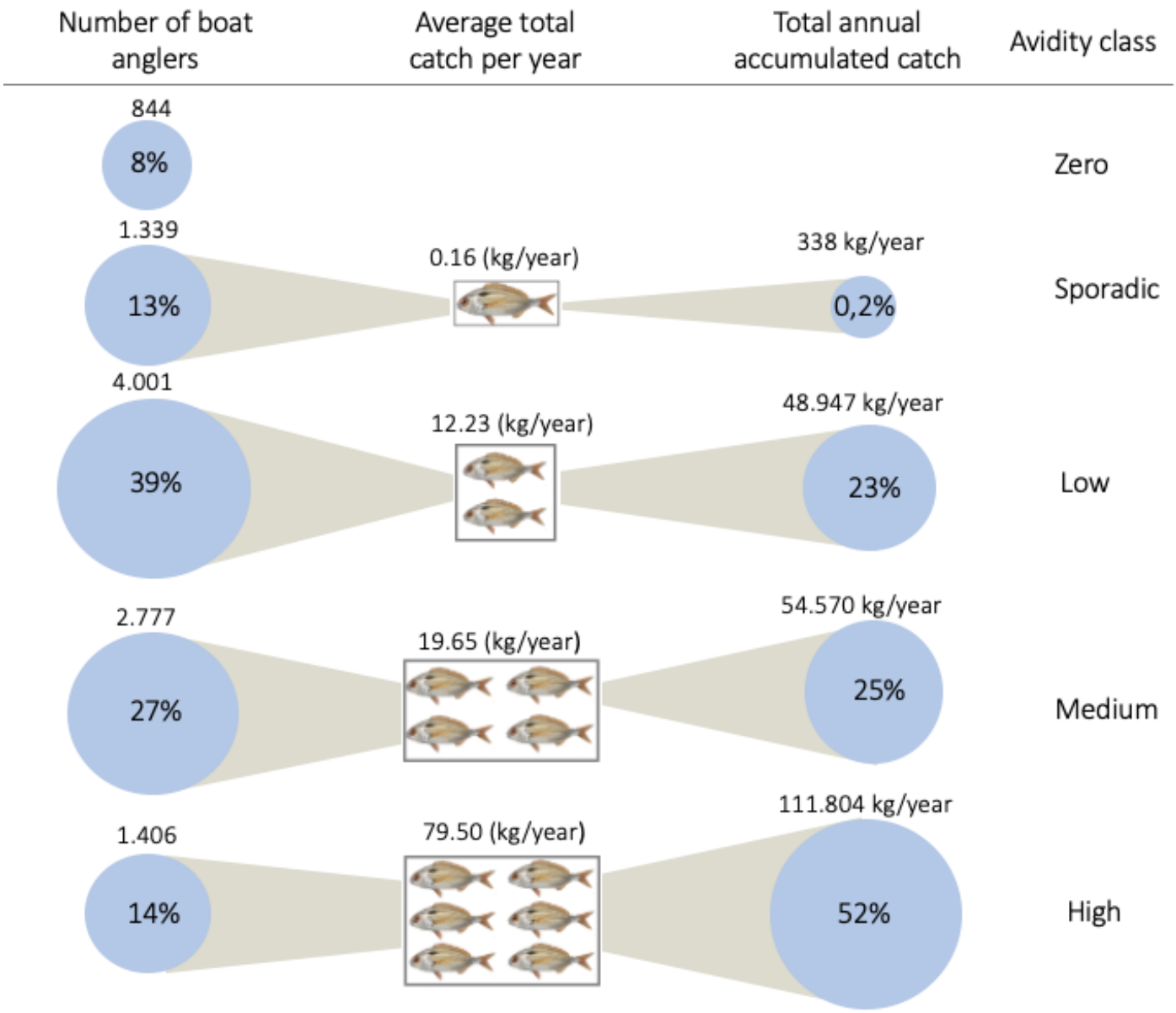

Figure 41: Number and proportion of boat angling, mean individual fishing intensity, and total accumulated catch per avidity group during 2021.

In 2022, over 58% of the boat anglers took less than 20 fishing trips during the 2022 period, jointly contributing 17% of the total modality catch. The remaining 27% who fished more than 20 days per year, of which 15% took over 50 trips, caught just under 83% of the total boat fishing catch. As a result, while sporadic avidity anglers caught on average a mere 0.78 kg, the low avidity recreational anglers extracted approximately 14 kg biomass during the one-year period. Conversely, medium avid class anglers extracted almost 36 kg per year, and the most avid anglers extracted a median of 100 kg throughout 2022 (Figure 42).

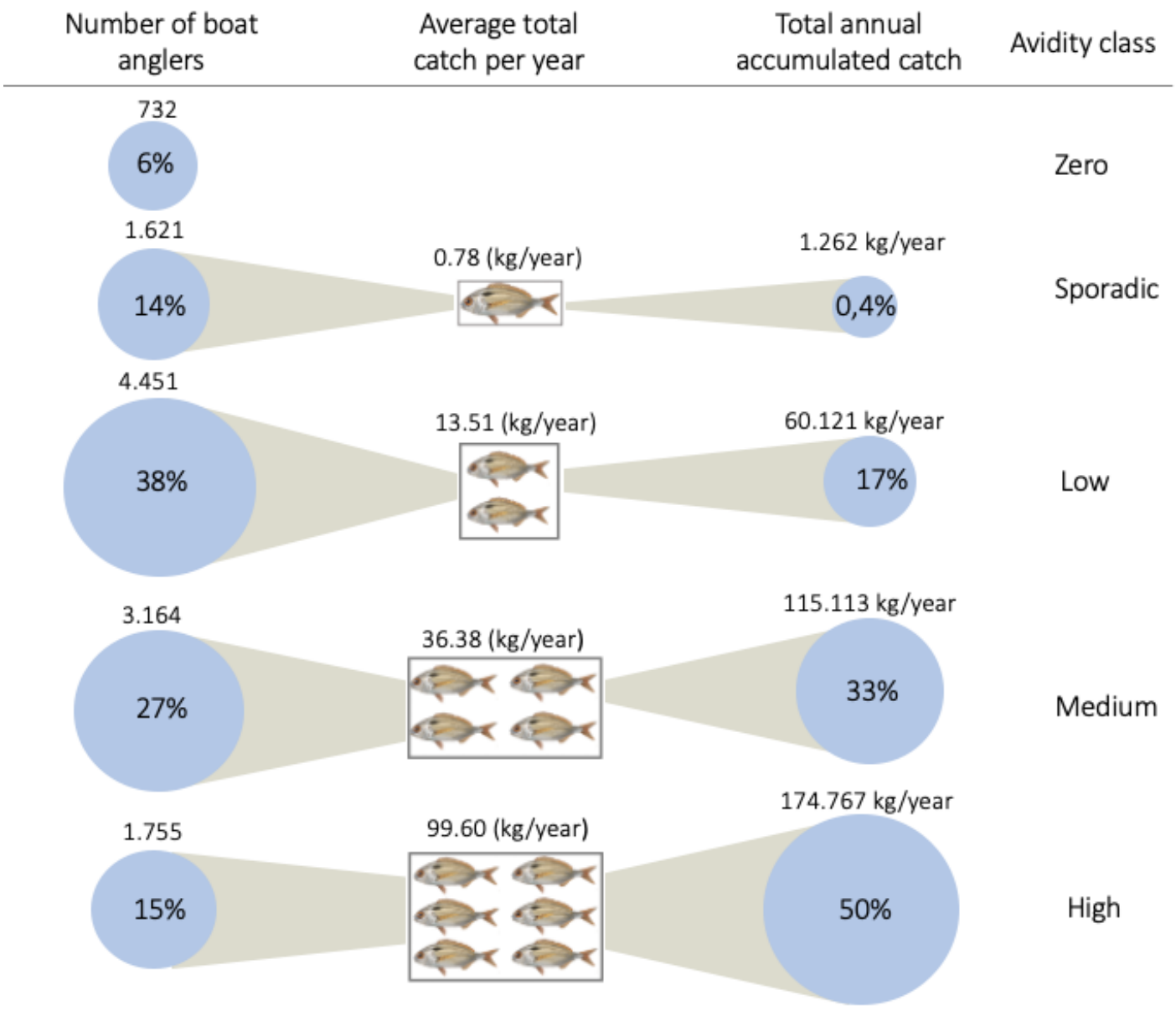

Figure 42: Number and proportion of boat angling, mean individual fishing intensity, and total accumulated catch per avidity group during 2022.

Spearfishing

5.3. Spearfishing

5.3.1. Fishing effort

The results of the spearfishing effort were based on annual effort distributions from the online surveys, which allowed to classify respondents into avidity classes based on their declared fishing effort during the past 12 months for each year (Table 9). The online survey only represents license-holders. Therefore, the effort distributions from the online surveys were extrapolated only to licensed fishers.

Table 9. Avidity class distribution of licensed for spearfishers.

	2021	2022
Zero	7%	5%
Sporadic (1 -2 days)	4%	3%
Low (3 -19 days)	44%	43%
Medium (20 -49 days)	35%	34%
High (+50 days)	11%	15%

The results showed a low proportion of individuals holding a recreational fishing license whom did not make any use of it during the years 2021 and 2022 (7% and 5%, respectively; Table 9). In the case of the sporadic avidity class, the percentage was the lowest and very similar for both years (4% in 2021 and 3% 2022). The majority of spearfishers showed low avidity effort patterns (44% and 43% in 2021 and 2022, respectively) followed by medium avidity class (35% and 34% in 2021 and 2022, respectively). Highly avid spearfishers accounted for 11% and 15% in 2021 and 2022, respectively.

The responses of the percentages obtained from the surveys were extrapolated to the number of active fishers to estimate the number of anglers by avidity category. The year-to-year variation was very small around 8% (Table 10).

Taula 10. Estimate total number of spearfishers of each year.

	2021	2022	Variation	% variation
Zero	184	142	42	-22.8
Sporadic (1 -2 days)	97	102	5	5.2
Low (3 -19 days)	1 206	1 286	80	6.6
Medium (20 -49 days)	965	1 002	37	3.8
High (+50 days)	306	452	146	47.7
Total	**2 758**	**2 985**	**227**	**8.2**

Reported annual fishing effort for spearfishers who went fishing at least once during 2021 showed an average of 22 fishing days per year, with a similar periodicity through the different seasons, ranging from 25 days per year in spring to 22 days per year in summer.

Similarly, reported annual fishing effort for shore anglers who went fishing at least once during 2022 showed an average of 25 fishing days per year, also with a similar periodicity through the different seasons ranging from 28 days per year in spring and winter to 23 days per year in summer.

The evaluation of the frequency of fishing days from the online surveys by answering the question: How many times have you gone fishing in the last 4 weeks? is reported as a monthly average by avidity class per season in 2021 and in 2022 (Table 11).

There is a similar tendency for both years, with the highest average obtained from the high avidity class, and it diminishes as the class progresses towards the sporadic category.

Table 11. Monthly average from 1 month analysed through online surveys by answering the question: *How many times have you gone fishing in the last 4 weeks?*

Year 2021	Zero	Sporadic	Low	Medium	High
Winter	0	0.02±(0.0)	0.33±(1.42)	0.97±(1.58)	4.69±(2.78)
Spring	0	0.07±(0.92)	0.93±(1.24)	2.55±(2.79)	5.67±(2.74)
Summer	0	0.16±(0.69)	2.18±(2.47)	4.34±(4.52)	8.39±(5.25)
Autumn	0	0.04±(0.0)	0.52±(1.04)	2.06±(2.85)	5.05±(3.64)
Year 2022	**Zero**	**Sporadic**	**Low**	**Medium**	**High**
Winter	0	0.04±(0.76)	0.60±(1.01)	1.27±(1.81)	5,80±(3.98)
Spring	0	0.10±(0.0)	1.39±(1.75)	2.39±(2.25)	6,80±(2.88)
Summer	0	0.12±(0.88)	1.68±(2.36)	4,41±(4.65)	8,38±(5.57)
Autumn	0	0.04±(0.50)	0.53±(1.41)	1.57±(1.97)	6,67±(4.66)

5.3.1.1. Effort distribution

The areas with the highest total fishing effort were the south of Costa Brava, followed by Costa del Garraf and Costa Daurada (Figure 43). In this modality, the most popular seasons were summer and spring, with a total annual fishing day of 28 187 and 13 952 in 2021 and 2022, respectively. Spearfishing was notably concentrated in the zones that are characterized by the abundance of rocky coastline and the presence of underwater reefs (Costa Brava, Costas del Garraf, Costa Daurada, Cap de Creus and Costa del Mongrí). Overall, the spearfishing effort accumulated an estimate of 64 916 fishing trips per year.

The average daily spearfishing trips per kilometre show the degree to which fishing activity is unevenly distributed at a temporal and geographical scales (Figure 44; Annex II). The most intensely fished zone is also the one with the rockiest areas of the Catalan coast, i.e. Montgrí Coast, with a yearly average of 0.8 fishing trips per kilometre, and Barcelonès, with a yearly average of 0.6 fishing trips per kilometre (see below Figure 44). Considering the differences in seasonal activity, the spatial distribution of shore fishers is fairly consistent across seasons.

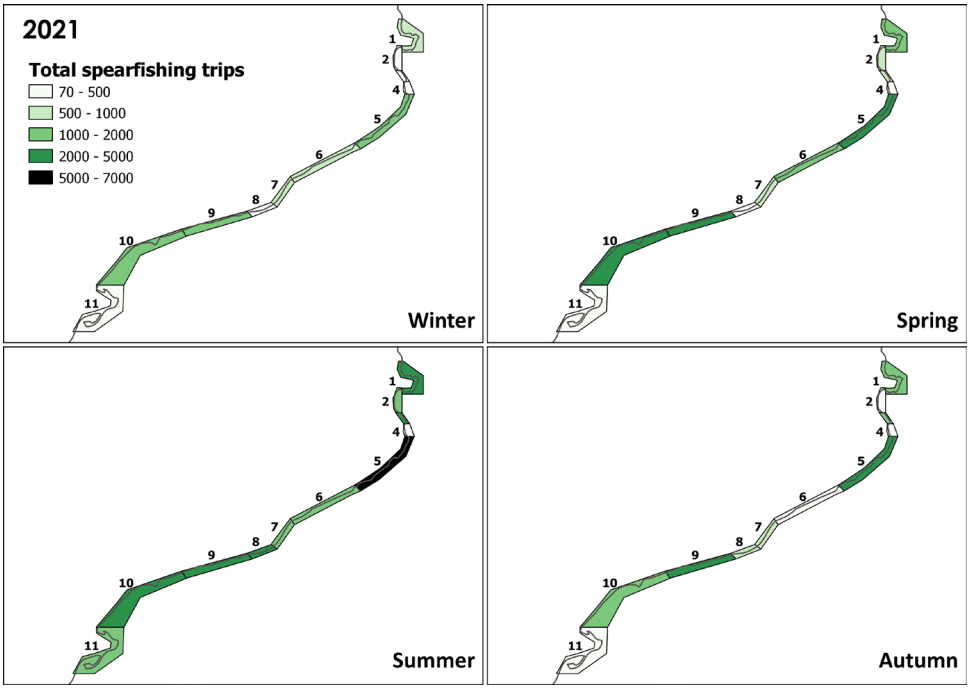

Figure 43. Total spearfishing trips during 2021 per zone during each season. In this analysis we do not take into account areas where fishing is not allowed.

Following the same analytical pattern, in 2022 the areas with most fishing days are the south of Costa Brava, Cap de Creus and Costa Daurada (Figure 45). In most areas, the season when most people go fishing is in summer, with around 31 150 fishing days. Most spearfishing trips are taken in the northern and central zones of the Catalan coastline (50%). Overall, the spearfishing effort accumulated an estimate of 82 846 fishing trips per year.

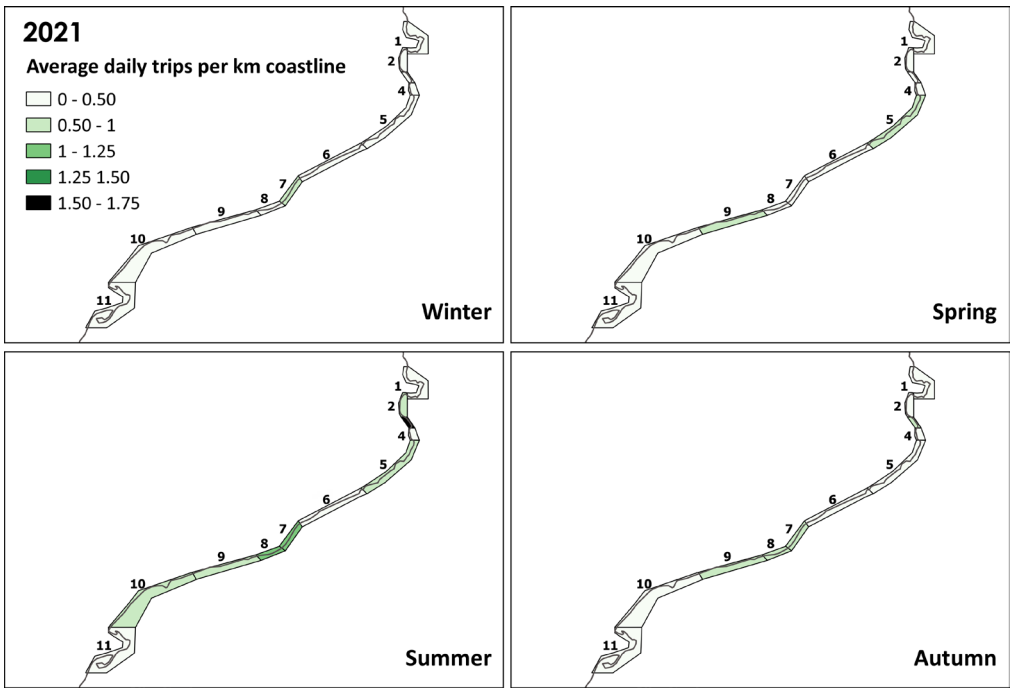

Figure 44. Average number of daily fishing trips during 2021 per kilometer coastline within each season.

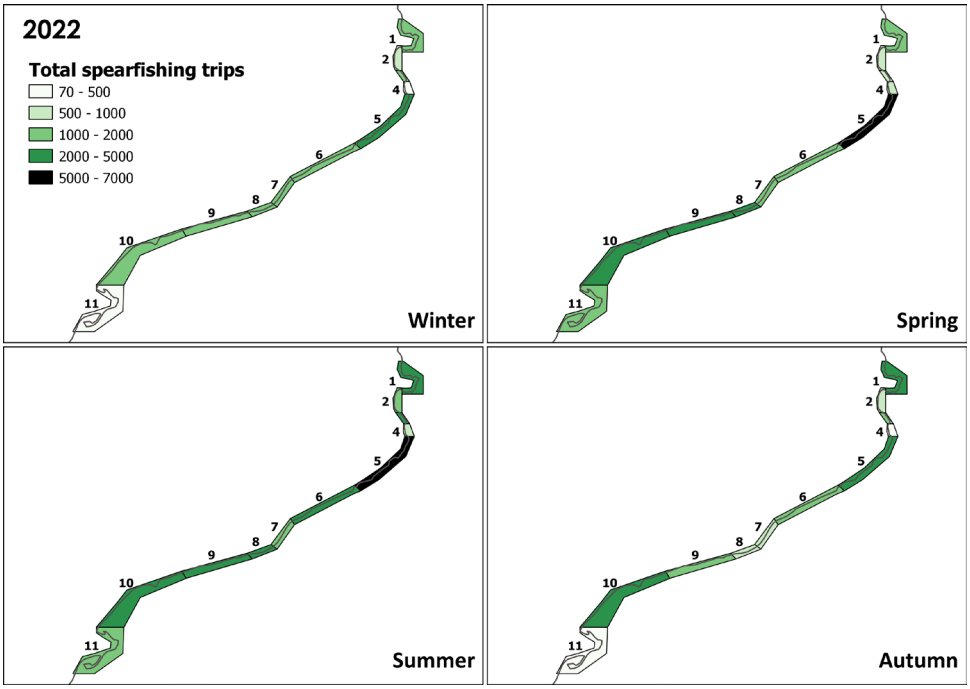

Figure 45. Total spearfishing trips during 2022 per zone during each season. In this analysis we do not take into account areas where fishing is not allowed.

The average daily spearfishing trips per kilometre in 2022 show the degree to which fishing activity is unevenly distributed at a temporal and geographical scales (Figure 46; Annex II). The Montgrí Coast and Delta del Llobregat hold the highest yearly average, with 1.1 and 0.9 fishing trips per kilometre, respectively (Figure 46). This might be due to two factors: first, the question in the online surveys may be misunderstood by the fishers because by predefining zones, it may not be clear what territory belongs to each zone; second, this area has an important but small point with breakwaters and rocks, turning a hot spot for spearfishers. Considering the differences in seasonal activity, the spatial distribution of shore fishers is fairly consistent across the seasons.

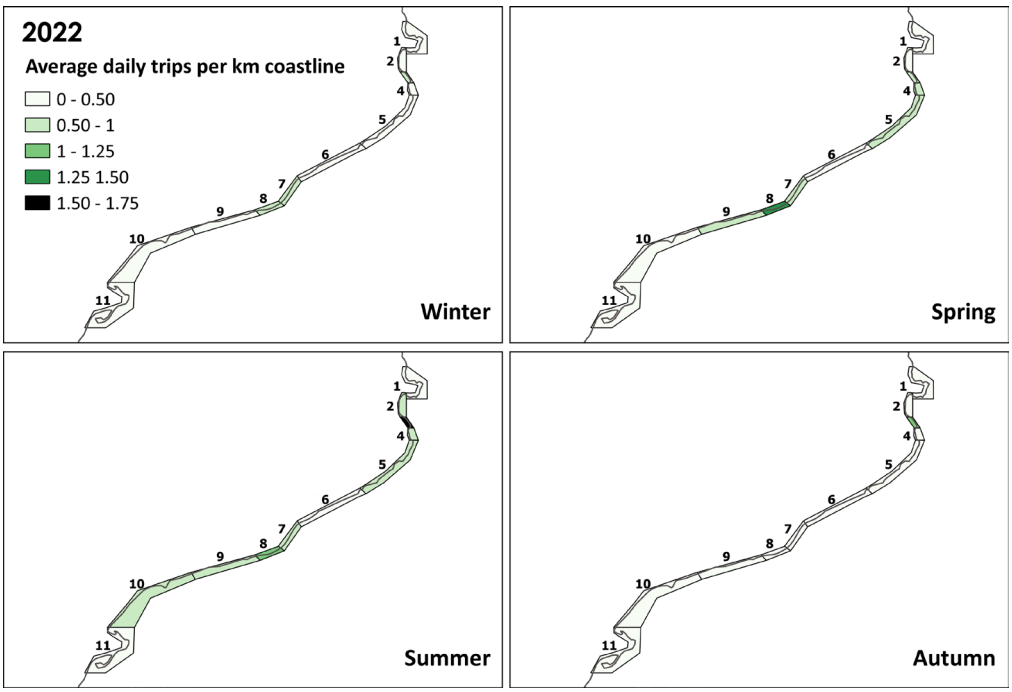

Figure 46. Average number of daily fishing trips during 2021 per kilometer coastline within each season.

5.3.2. Fishing yield

Fishing yield was analysed using catch per unit effort (CPUE) measured in kilograms caught per day fished. Comparing the two years studied we see that there was a significant difference (p-value=0.003) using a Wilcoxon rank with continuity correction. In detail, the average of CPUE in 2022 was higher (1.66±1.69) than that from 2021 (1.32±1.90; Figure 47).

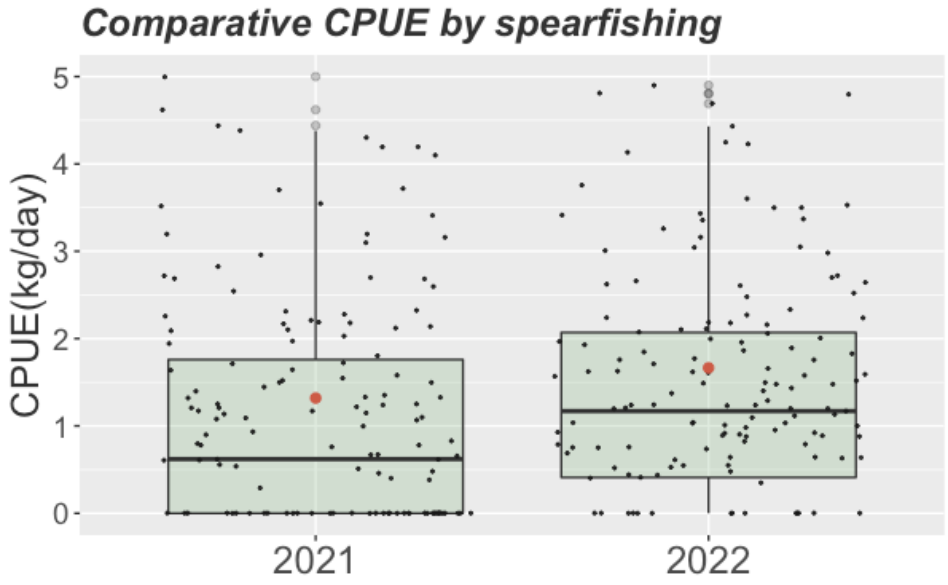

Figure 47: CPUE by 2021 and 2022 for spearfishing. The red rot indicates the mean, the horizontal black line represents the median the boxes represent the interquartile ranges (25 – 75%) and the vertical line represents the 90% spread of the data.

There were also significant differences (p-value=0.006) in CPUE for spearfishing among seasons in 2021. In detail, the difference was between spring and winter (p-value=0.007). The average of CPUE was 1.93±2.38, 1.23±1.66, 1.14±1.07, and 0.97±1.84 for spring, summer, autumn and winter, respectively (Figure 48).

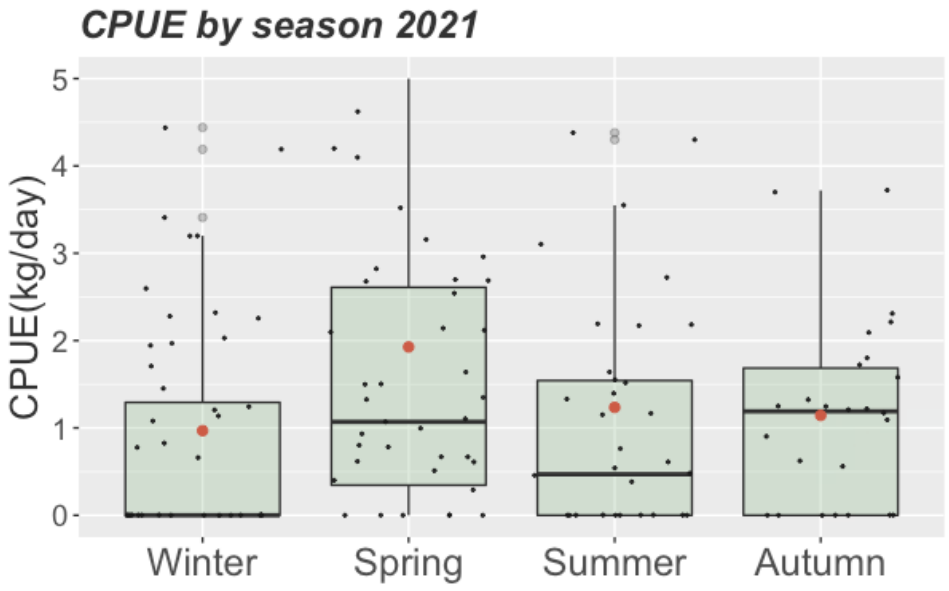

Figure 48. CPUE by season in 2021 for spearfishing. The red rot indicates the mean, the horizontal black line represents the median the boxes represent the interquartile ranges (25 – 75%) and the vertical line represents the 90% spread of the data.

In contrast, there were no significant differences (p-value=0.835) in CPUE for spearfishing among seasons in 2022. The average of CPUE was 1.53±1.45, 1.55±1.45, 1.92±1.92, and 1.74±2.18 for spring, summer, autumn and winter, respectively (Figure 49).

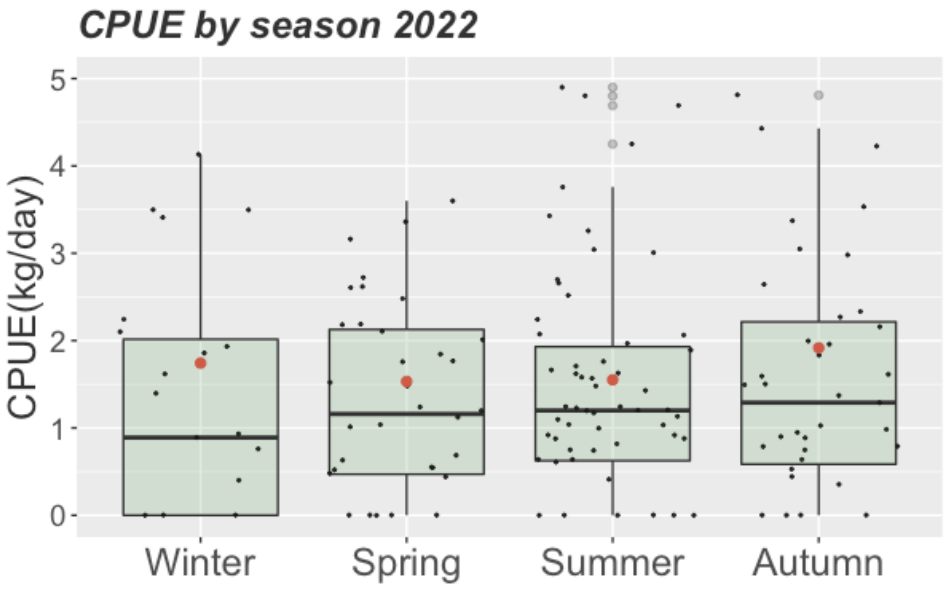

Figure 49. CPUE by season in 2022 for spearfishing. The red rot indicates the mean, the horizontal black line represents the median the boxes represent the interquartile ranges (25 – 75%) and the vertical line represents the 90% spread of the data.

5.3.3. Intended target species

Recreational fishers mostly have a specific catch or set of catches in which they are interested. It must be considered the intended target species are merely a declaration of intentions, and do not necessarily reflect the eventual outcome of a fishing trip, but they can be considered an important motivation axis setting the expectations for a given fishing trip. Spearfishing is a particularly selective activity, and this selectivity is highly determined by the different spearfishing strategies that can be used underwater. High catch selectivity allows the spearfishing activity to be much more targeted towards certain desirable catches, but it is also restricted to more coastal species.

In 2021, the main intended target species are *Sparus aurata*, followed by *Dicentrarchus labrax*, and *Dentex dentex*. Also, the main cephalopod caught is the common *Octopus vulgaris*. There is also interest to catch *Epinephelus marginatus*, *Sciaena umbra*, and *Phycis phycis*.

The intended target species from 2022 are very similar between both studied years, 2021 and 2022, aiming to catch *Sparus aurata*, followed by *Dentex dentex*, and *Dicentrarchus labrax*. As a difference, in 2022 appear two other species, sea urchins (*Paracentrotus lividus*) and *Sepia officinalis* (Figure 50).

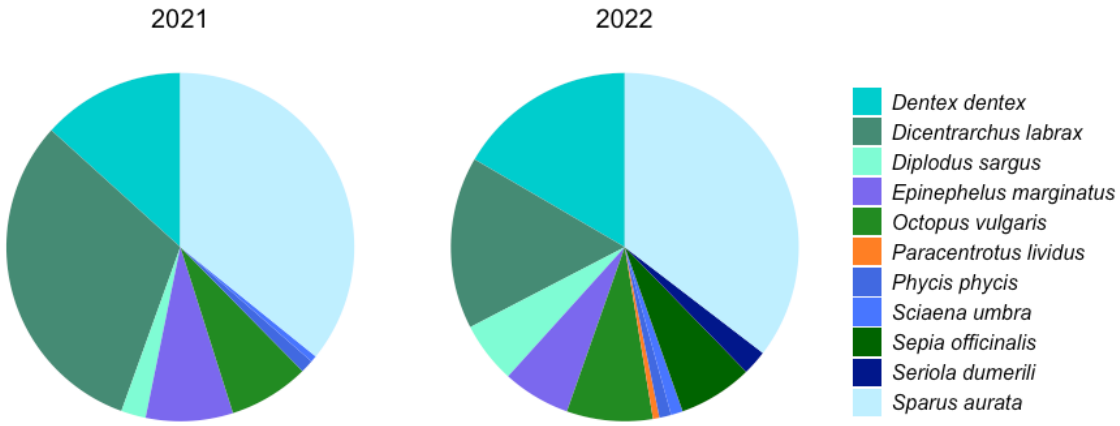

Figure 50: Percentage of spices according to declared as target by spearfishing in 2021 and 2022.

5.3.4. Seasonal catch composition

In the onsite sampling, a total 603 individual catches from spearfishing were identified from a total 29 different species during the studied years. Catch composition results show the actual catch estimates obtained from the onsite surveys. They contrast with results from target species, and it is clear that for all three fishing modalities, there is a difference between species desirability and their actual catchability. Species' catch seasonality may also be observed, as different species are more or less available, or more or less desired during different times of the year.

Seasonal species catch composition differences can also be observed for spearfishing in each year. Spring was found to be the season with the highest biodiversity, with 18 different species observations (Annex IV, Figure 74B; note that only species with over 1% of the total catch are represented), followed by summer with 15, autumn with 14 and finally winter with 10 different species out of the 22 total different species observed in 2021. Increased in 2022, summer was again found to be the season with the highest biodiversity, with 21 different species observations (Annex V, Figure 75C; note that only species with over 1% of the total catch are represented), followed by autumn with 17 and finally spring and winter with 15 different species out of the 29 total different species observed. Lower catch diversity is expected for spearfishing, as it is a more selective activity. This can be observed by the scarcity of species in the catch compositions that are not present in the declared target species list (Figure 50). However, it must be noted that contrasting spearfishing catch diversity with the other two fishing modalities is compromised by the considerably lower number of surveys conducted for spearfishing (348 surveys, years together).

Catch composition results show the actual estimates obtained from the onsite surveys. There were some similarities and differences among seasons between both studied years. In winter, the two main species were the same, *O. vulgaris* (32.8% and 28.4% in 2021 and 2022, respectively) and *D. labrax* (35% and 16.2% in 2021 and 2022, respectively). However, in 2022 there was a higher diversity of fished species than in 2021. In spring, *S. officinalis* was the main species in 2022 (35%) but it was absent in 2021. The dominant species from 2021 was *E. marginatus*, with 16.9%. In summer, the main species were very similar between years, i.e. *D. dentex* (21.1% and 21.7% for 2021 and 2022, respectively), *D. sargus* (15.1% and 19.5% for 2021 and 2022, respectively) and *E. marginatus* (12.7% and 18.8% for 2021 and 2022, respectively). However, *S. umbra*, which was also fished in 2021 (15.6%), was absent in 2022. Autumn had different species for both years, with *O. vulgaris* being the most fished species in 2021 (23.2%) but it was much scarce in 2022 (4.3%; Figure 51).

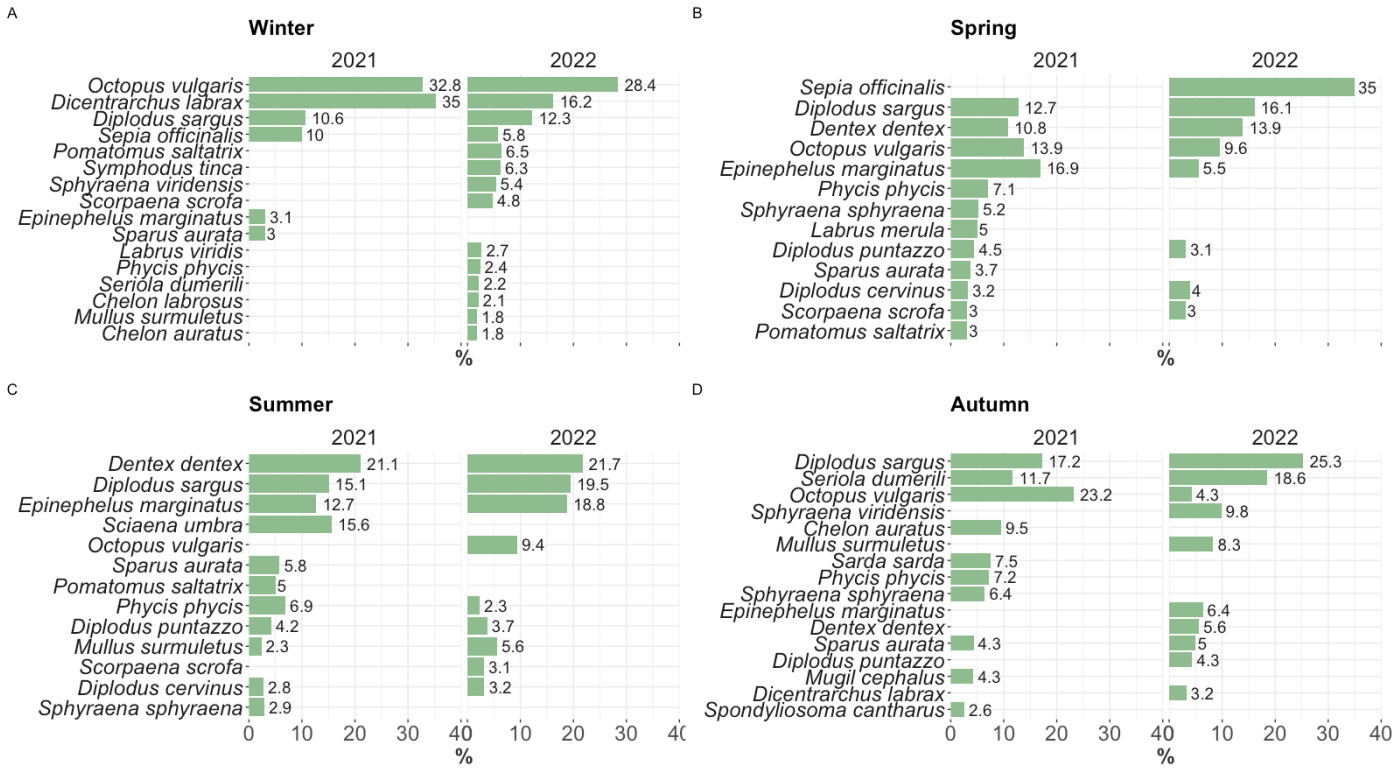

Figure 51: Catch composition (in weight %) by spearfishing in winter (A), in spring (B), in summer (C) and in autumn (D) during 2021 (left) and 2022 (right).

5.3.5. Total annual catch

Estimates of total annual catches used catch data from the onsite surveys and effort values from the online surveys. Regarding the main total catches on spearfishing modality in 2021 (Figure 52), was *Octopus vulgaris* (16 036 kg). The second most relevant species was *Diplodus sargus* with 12 315 kg total annual catches, followed by *E. marginatus* with 9 001 kg total annual catches and *Dicentrarchus labrax* (8 190 kg). Remarkably high catch values were obtained for *Dentex dentex* (7 951 kg), which contrast significantly with results from previous studies (ICATMAR, 2022, ICATMAR 2020a; Dedeu et al., 2019).

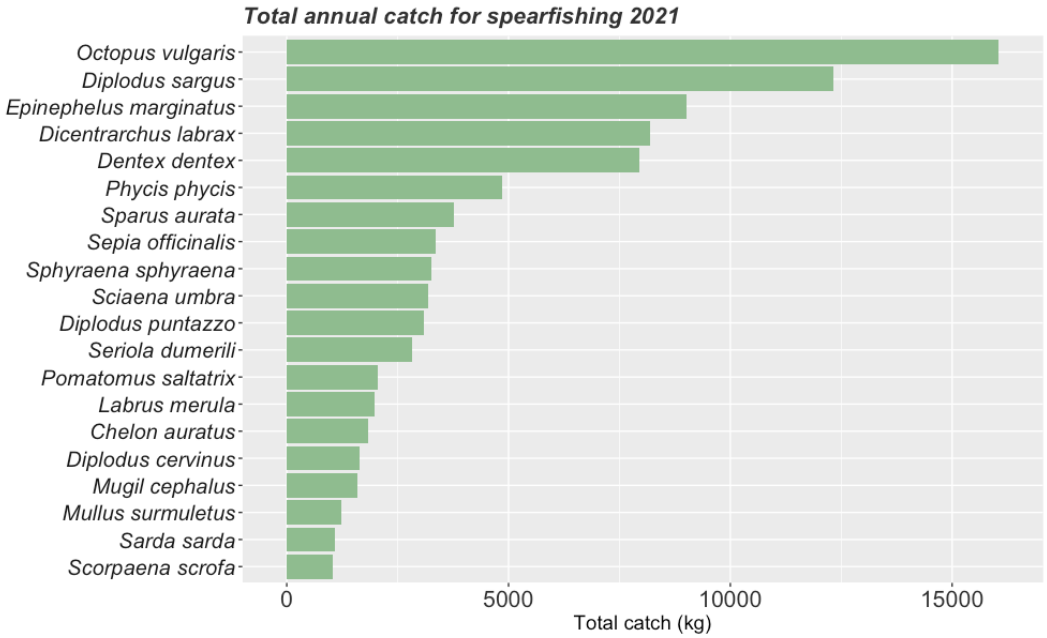

Figure 52: The total annual catch per species for spearfishing in 2021. Only species with a relative weight above 1% of the total catch are shown. The graph shows 98% of the total catch.

When analyzing the catch by number of individuals instead of mass, the species mostly caught in 2021 were 22 070 individuals of *D. sargus*, 9 521 individuals of *O. vulgaris*, and 8 222 individuals of *M. surmuletus* (Figure 53). Interestingly, despite that *E. marginatus* was the third more fished species in mass, it only represents about 3 000 individuals meaning that the individuals caught were of larger size than those caught by spearfishing.

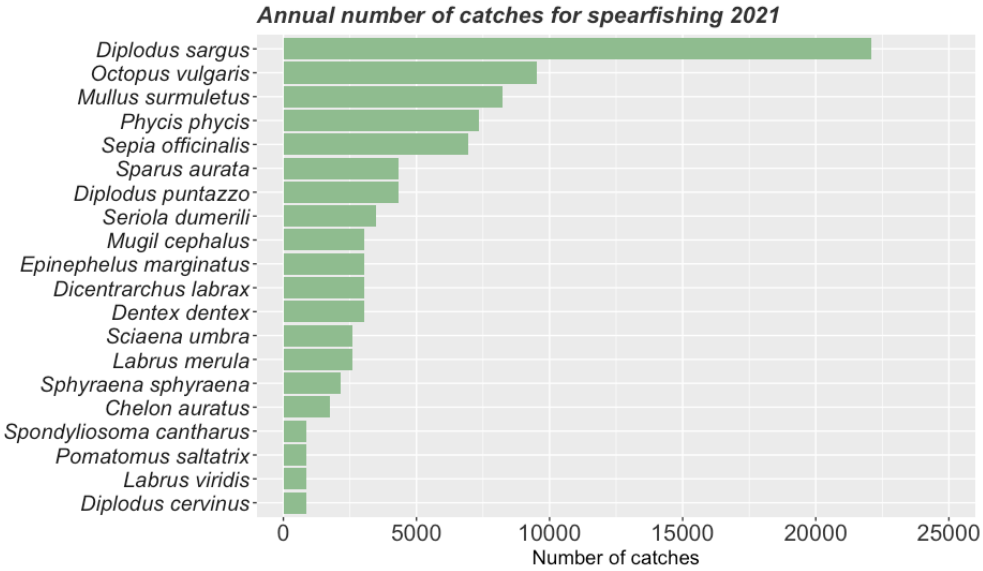

Figure 53: Estimation the total annual catch per species for spearfishing in 2021.

In 2022, estimates of total annual catches used catch data from the onsite surveys and effort values from the online surveys. Regarding the main total catches on spearfishing modality in 2022 (Figure 54), was *Diplodus sargus* (22 575 kg). The second most relevant species was *Dentex dentex* with 14 520 kg total annual catches, followed by *Octopus vulgaris* with 12 434 kg total annual catches and *Sepia officinalis* (11 574 kg).

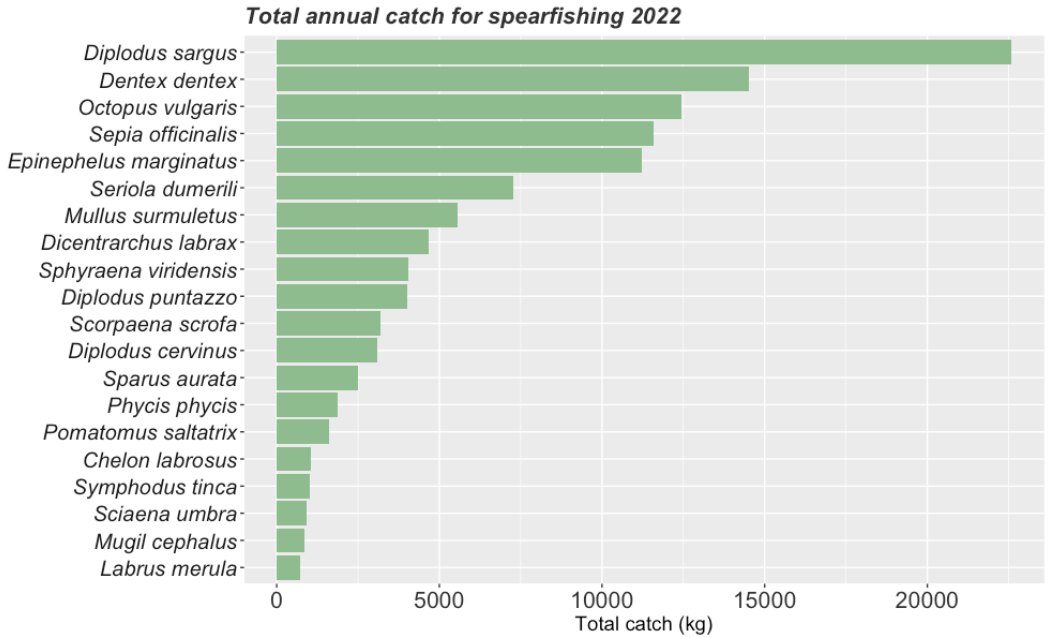

Figure 54: The total annual catch per species for spearfishing in 2022. Only species with a relative weight above 1% of the total catch are shown. The graph shows 98% of the total catch.

The species mostly caught in 2022 were 24 853 individuals of *Sparus aurata*, 19 164 individuals of *Mullus surmuletus*, and 14 972 individuals of *Paracentrotus lividus*. As observed in 2021, despite that *Epinephelus marginatus* was a main fished species in mass, it represents about 2 000 individuals caught were of larger size than those caught by spearfishing (Figure 55).

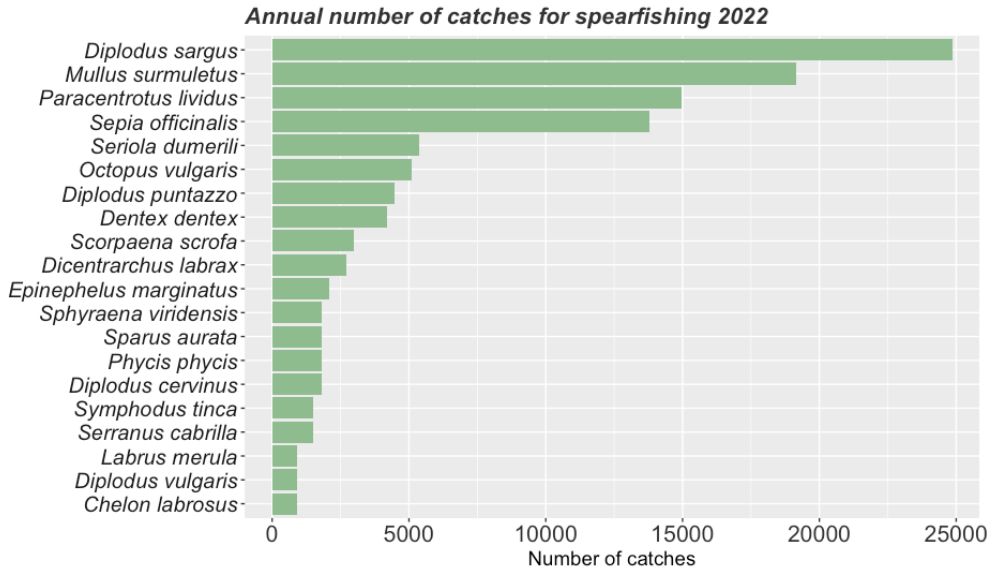

Figure 55: Estimation the total annual catch per species for spearfishing in 2022.

5.3.6. Distribution of the total annual catch

The zones with more catches are very similar between both studied years. However, in 2022, there are more annual catches, in general, compared to 2021, especially in the areas south of Costa Brava, Costa daurada, Costes del Garraf, and Cap de Creus. The spatial distribution of the annual catches evidences the ranging fishing impacts (Figure 56). In general, the most populated areas such as Barcelona and it is adjacent zones yield the highest amount of catches on a per kilometre basis.

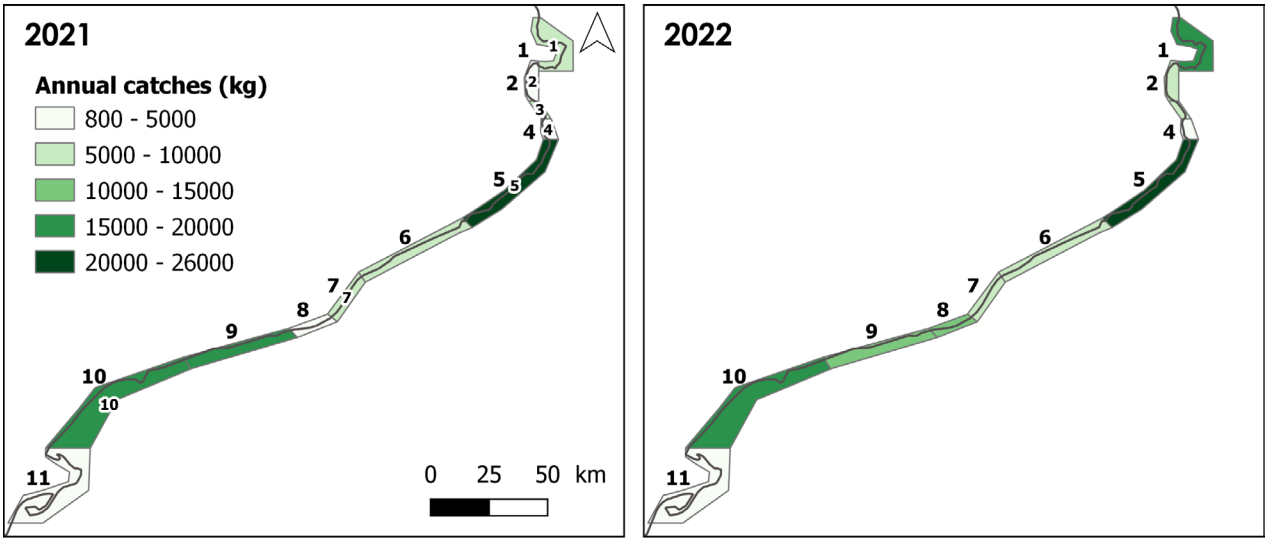

Figure 56: Distribution of total annual catch by spearfishing in 2021 (left) and 2022 (right).

5.3.7. Inequality in the distribution of the total annual catches

Spearfishing is one of the most selective and efficient forms of fishing. In the division of the typology of fishers according to their avidity class to go fishing in the online surveys, we found, in both years, a small percentage who got their license but did not go fishing or went only a few days. The different avidity groups designed in this study are responsible for very different proportions of the total catches. Below are the figures corresponding to spearfishing modality in 2021 and 2022, where the number of anglers in each avidity class is directly associated with their relative contributions to the total modality catch. Relative individual impacts vary enormously in relation to their avidity patterns. These amount to massive differences in the aggregate impact of each avidity class. It must be considered that the values presented are the product of estimations based on extrapolations that, although consistent with the avidity class model are not based on direct observations, and should therefore be observed with caution.

For spearfishing, over 55% of the fishers took less than 20 fishing trips during the 2021 period, jointly contributing 17% of the total modality catch. The remaining 35% who fished more than 20 days per year, of which 11% took over 50 trips, caught 84% of the total spearfishing catch. These enormous inequalities in the relative contributions to the total catch are explained by the positive synergy between avidity and catch rates. This results in the stark observed differences in annual catch extractions between avidity classes. While sporadic avidity fishers were not found in the onsite survey, the low avidity recreational anglers extracted approximately 12.55 kg biomass during the one-year period. Conversely, medium avid class anglers extracted almost 35 kg per year, and the most avid anglers extracted a median of 135 kg throughout 2021 (Figure 57).

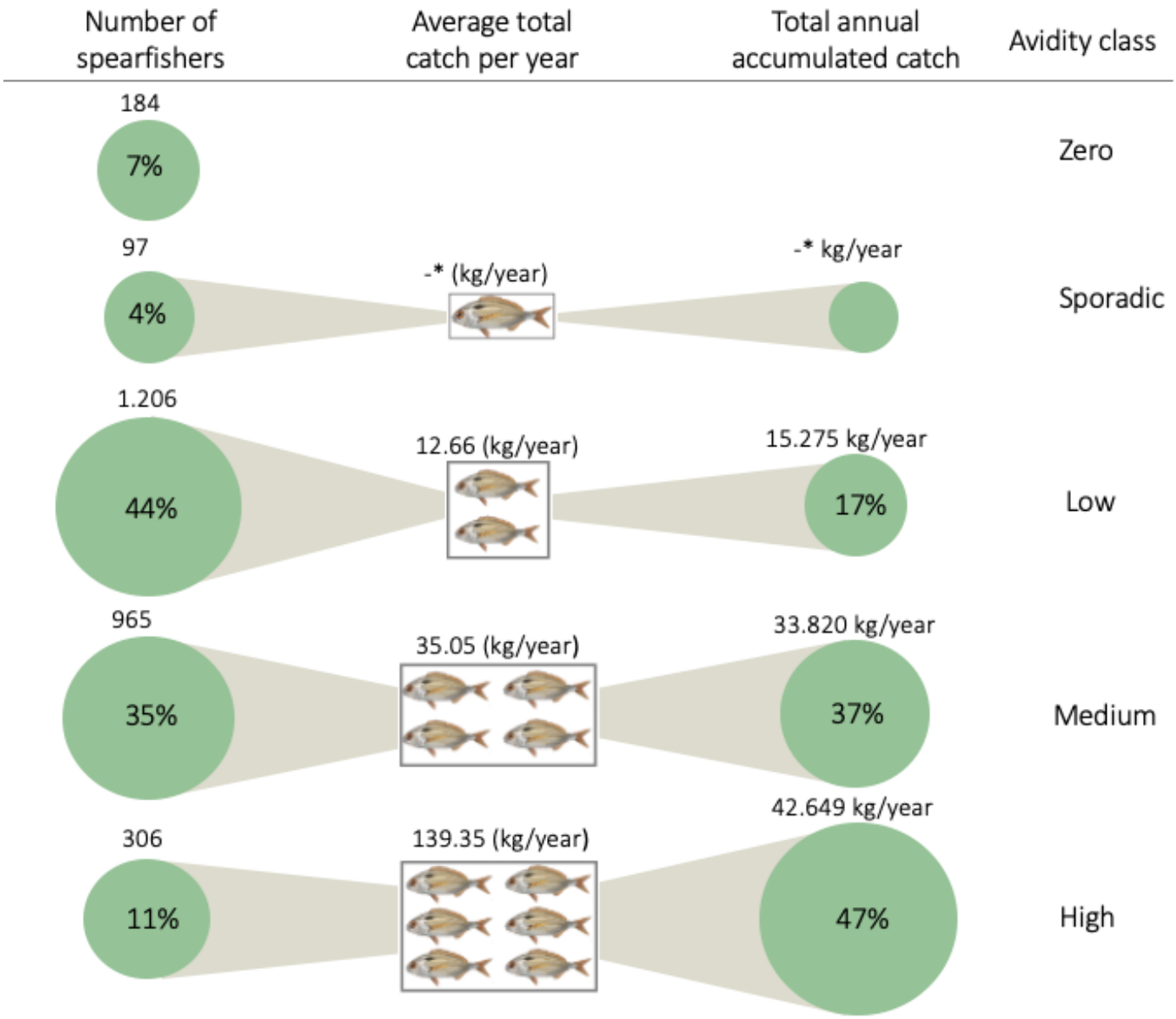

Figure 57: Number and proportion of spearfishing, mean individual fishing intensity, and total accumulated catch per avidity group during 2021. (*) On the onsite surveys, the sporadic avidity class was not reported and, hence, these results have not been considered for the final estimation.

In 2022, spearfishing also shows a similar catch trends among the different avidity classes, with the 51% of the spearfishers who fished less than 20 days per year contributing only a 12% of the total modality catch, while the more avid 49% who took than 20 fishing trips throughout the year jointly accumulate the remaining 88%. Notoriously, the estimated 452 (15%) most avid recreational spearfishers individually caught an average 111 kg throughout the natural year, accounting for over half (43%) of the total annual catches for the whole modality and contributing significantly to the total catch for the whole of the MRF activity (Figure 58).

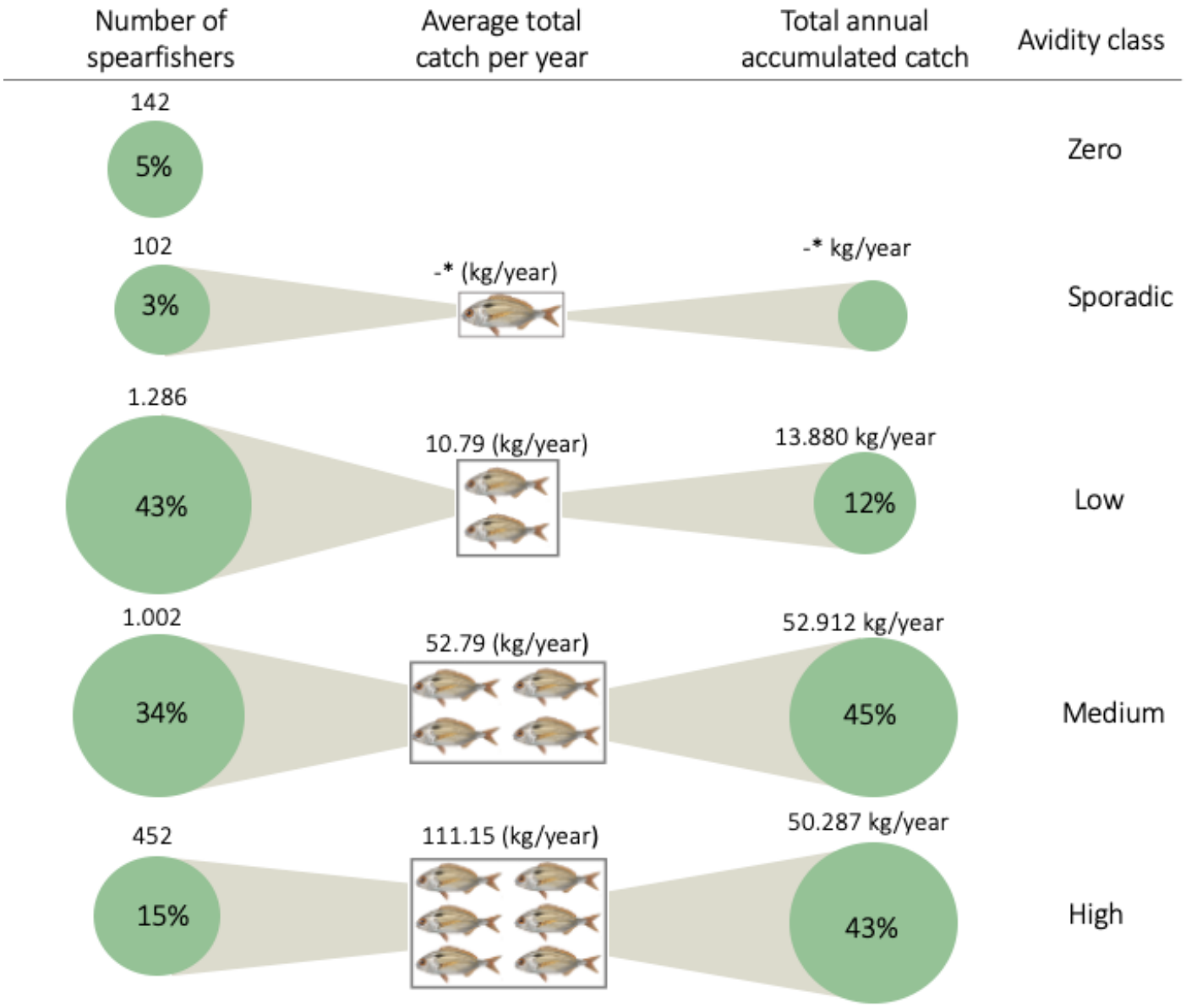

Figure 58: Number and proportion of spearfishing, mean individual fishing intensity, and total accumulated catch per avidity group during 2022. (*) On the onsite surveys, the sporadic avidity class was not reported and, hence, these results have not been considered for the final estimation.

5.4. Distribution the total annual catch by modalities

Estimates of total annual catches used catch data from the onsite surveys and effort values from the online surveys and were estimated first for each avidity class within each season, after which they were added into seasonal total catch values for the whole modality. The total annual catch for shore angling in 2021 was 202 706 kg per year and, in 2022 increased to 310 890 kg per year. Boat angling accumulated 215 659 kg per year in 2021 and, in 2022 increased to 351 264 kg per year. Finally, for spearfishing in 2021 was 91 744 kg per year and, in 2022 increased to 117 078 kg per year.

The spatial distribution of the annual catches evidences the ranging fishing impacts of the different fishing modalities along the Catalan coast (Figures 59 and 60). Overall, catches by shore and boat angling increased in 2022 compared to 2021 on virtually the entire coastline. As for spearfishing, a slight increase in catches was recorded in the northern area, specifically in the Costa Brava Sud zone. In both years, spearfishing catches were considerably lower in zones dominated by sandy bottoms (Delta de l'Ebre, the Golf de Roses and Delta del Llobregat).

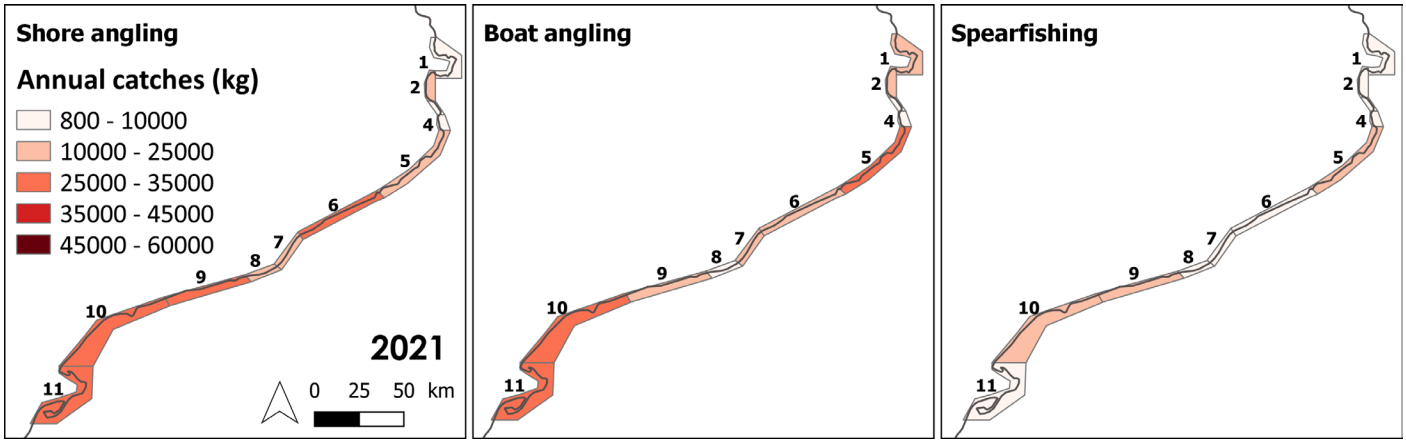

Figure 59: Distribution of total annual catch by modalities during 2021.

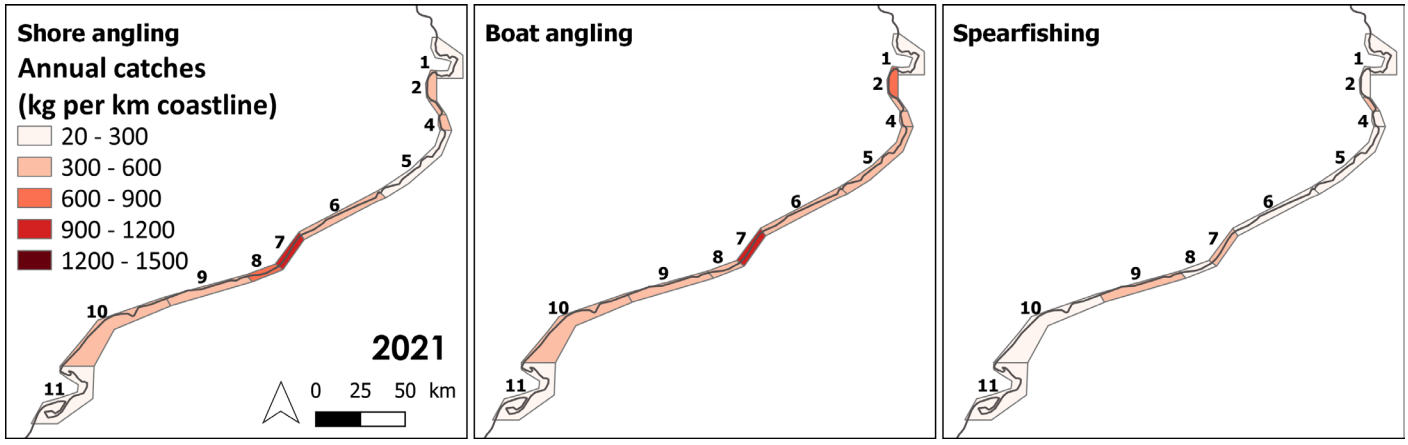

Figure 60: Distribution of total annual catch per kilometre coastline by modalities during 2021.

When the catch was standardised on a per km basis, all kilometres were taken into account without considering the areas where marine MRF is not allowed (Figures 61 and 62). In this case, for the three modalities the most populated areas such as Barcelona and its adjacent zones yielded the highest amount of catches in both 2021 and 2022. Population density and fishing extraction were particularly related in the case of shore angling in 2022.

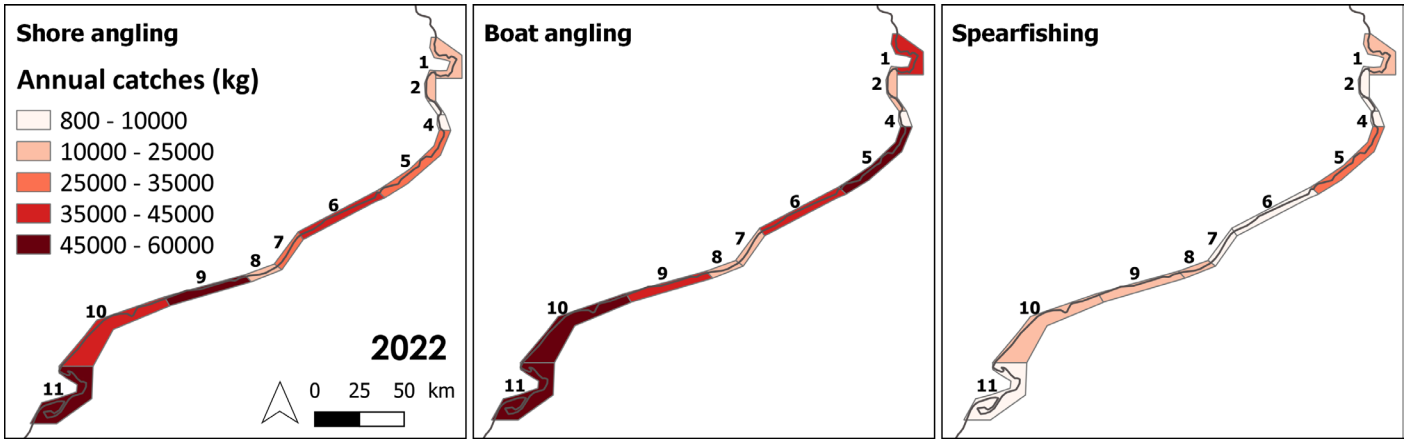

Figure 61: Distribution of total annual catch by modalities during 2022.

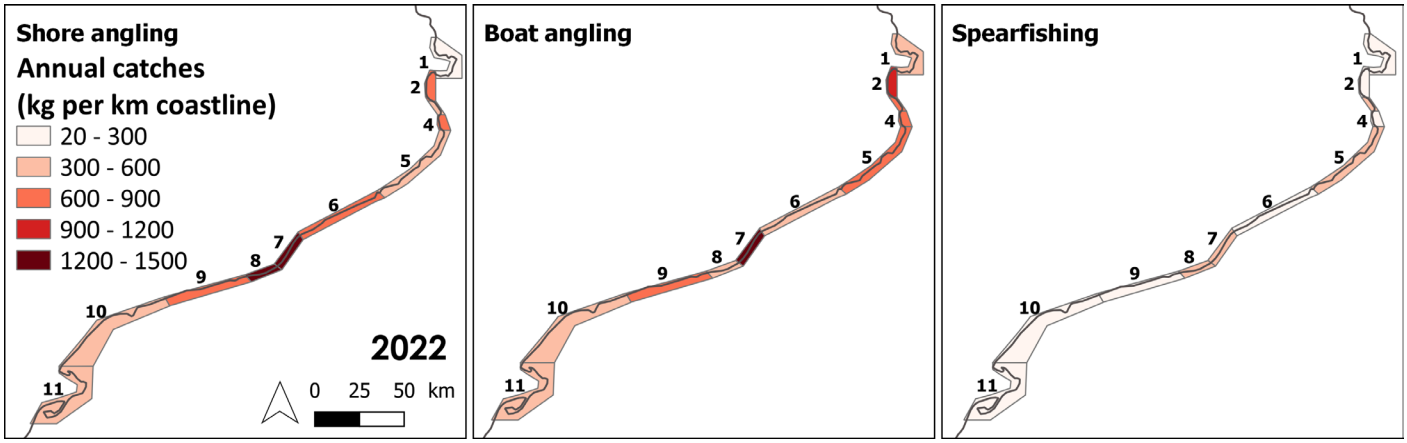

Figure 62: Distribution of total annual catch per kilometre coastline by modalities during 2022.

6

Pilot study of the data derived from the police control action of CME and CAR

A coordinated and target control campaign on recreational marine fisheries was conducted by GDGPMPS with the CME (Cossos Mossos d'Esquadra) and the CAR (Cossos d'Agents Rurals). Therefore, an intensive 15-day campaign was carried out along the Catalan coast in October 2022 with the aim of intercepting unlicensed marine recreational fishers. During the campaign, 688 marine recreational fishers were examined, 635 of whom were in possession of a licence. Of these, 562 had their licenses emitted in Catalonia and 73 outside of it. Of the 615 marine recreational fishers intercepted in Catalonia, 436 belonged to shore anglers, 142 to boat anglers and 37 to spearfishers. Regarding the unlicensed recreational marine fishers intercepted, 43 were shore anglers (9.9%), 6 were boat anglers (4.2%) and 4 were spearfishers (10.8%; see table 12). Looking at the percentages for the pilot test in 2019, these are higher because the surveys were addressed to the whole population. That is, the online survey link was shareable.

Table 12. Percentatge dels pescadors recreatius marins sense llicència interceptats durant la campanya de l'octubre del 2022 (primera columna) i durant l'estudi pilot al 2019 (ICATMAR, 2020a).

	Fishers unlicenced (%) Police pilot study (2022)	Fishers unlicenced (%) study (2019) Pilot
Shore angling	10%	23%
Boat angling	4%	10%
Spearfishing	11%	20%

Tables 13 and 14 below show a comparison between the MRF annual catch and an estimation of the MRF annual catch for 2021 and 2022 in Catalonia including the catch by unlicensed marine recreational fishers using the percentages obtained during the October 2022 police campaign and the 2019 pilot study. The presence of unlicensed marine recreational fishers hampers the ability to assess actual catches and therefore complicates the management of this activity considerably

Table 13. Estimation the total annual catch (kg) included unlicenced recreational fishers with the police pilot study percentage.

Police October 2022	Total annual catch (2021)	Total annual catch with unlicenced fishers	Total annual catch (2022)	Total annual catch with unlicenced fishers
Shore angling	202 706	222 774	310 890	341 668
Boat angling	215 659	224 717	351 264	366 017
Spearfishing	91 836	101 754	117 159	129 812
Total annual	**510 201**	**551 245**	**779 313**	**837 497**

Table 14. Estimation the total annual catch (kg) included unlicenced recreational fishers with the pilot study percentage.

Pilot study 2019	Total annual catch (2021)	Total annual catch with unlicenced fishers	Total annual catch (2022)	Total annual catch with unlicenced fishers
Shore angling	202 706	249 328	310 890	382 395
Boat angling	215 659	237 225	351 264	386 390
Spearfishing	91 836	110 203	117 159	140 591
Total annual	**510 201**	**596 756**	**779 313**	**909 376**

7

Social profile of marine recreational fishers

Recreational fishing in Catalonia is a highly gendered activity as most participants are men, with women only taking a marginal role in the activity. During the 2021 onsite surveys, 1 478 fishers identified as men and only 29 as women (Figure 63). As for the online surveys, 5 772 fishers identified as men and 330 as women (Figure 64). These results are highly consistent with those of the latest report (ICATMAR, 2022) and the pilot study (ICATMAR, 2020a).

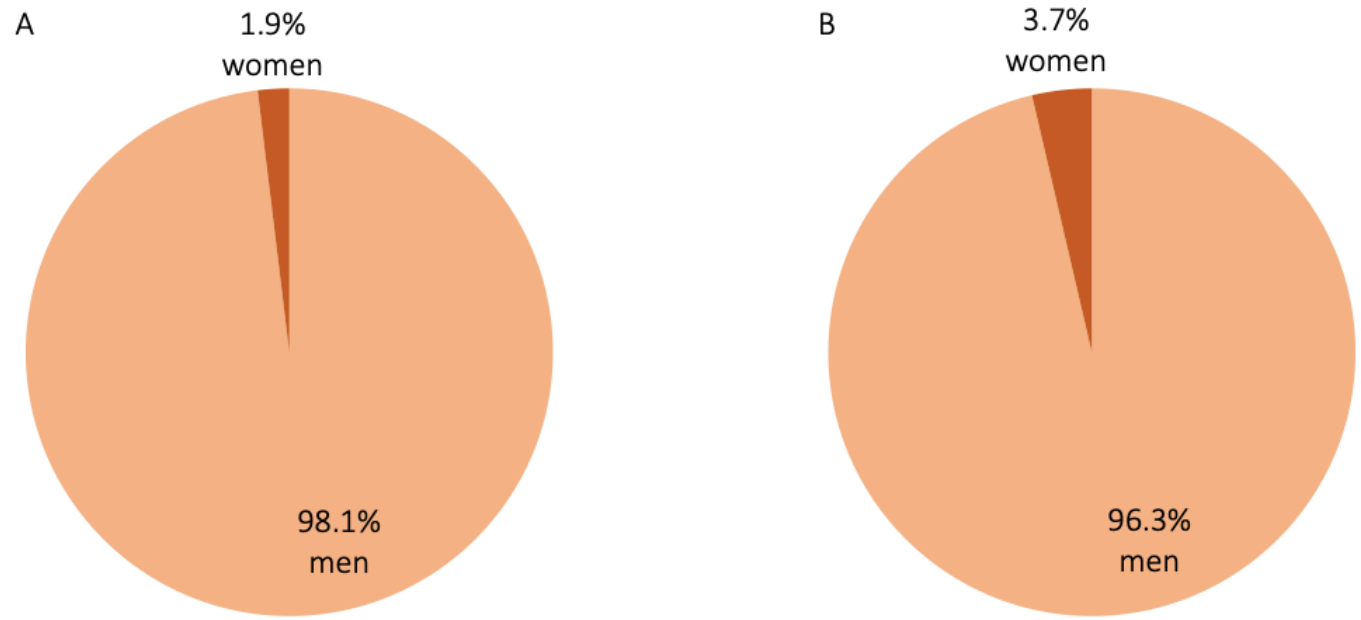

Figure 63: Percentage of responses by gender from onsite surveys in 2021 (A) and 2022 (B).

In 2022, the results of the onsite surveys were similar: 1 346 fishers identified as men and there was a slight increase in the number of women to 51 (Figure 63). As for the online surveys, 4 382 fishers identified as men and 259 as women in 2022 (Figure 64).

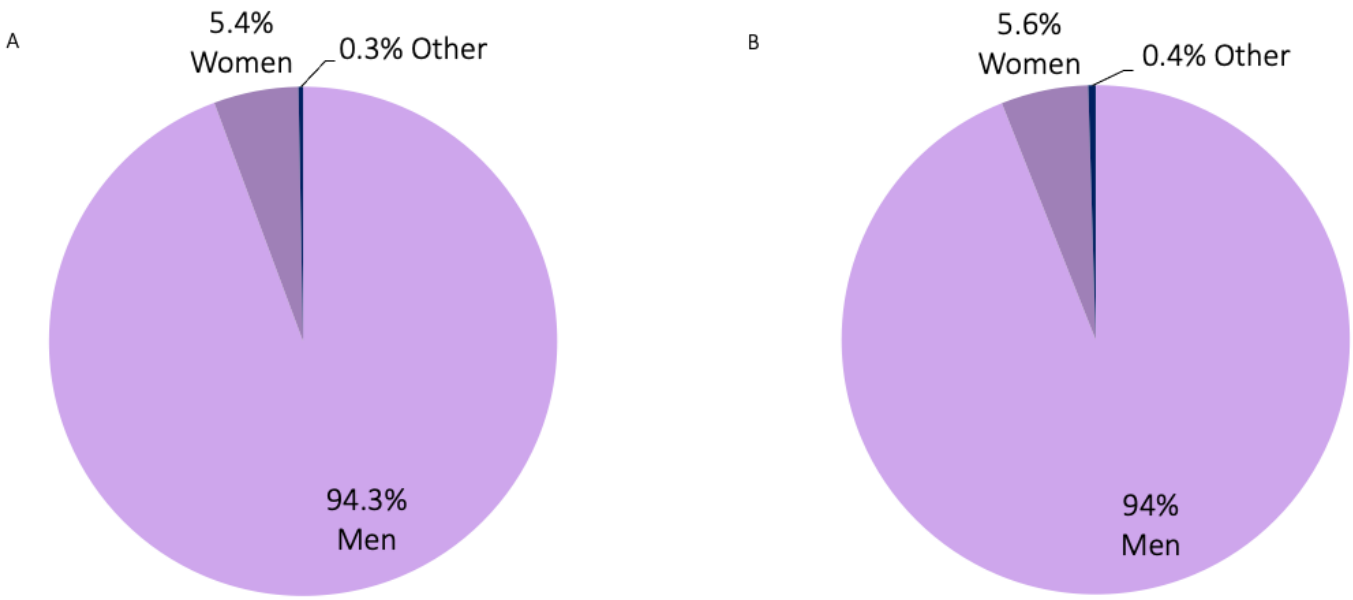

Figure 64: Percentage of responses by gender from online surveys in 2021 (A) and 2022 (B).

As for the language selected by fishers to fill the online survey in both 2021 and 2022, the most chosen language was Spanish, followed by Catalan, French and finally English.

Regarding the average age of marine recreational fishers, the difference between 2021 and 2022 is minimal for both the onsite and the online surveys. In the onsite surveys the average age was 45 and 44 for 2021 and 2022 respectively, and in the online surveys it was 48 and 50, respectively. This suggests that the online dissemination strategy may allow reducing the electronic age-bias effect significantly; thus, the e-mails with the online survey targeted specifically to recreational fishing licence holders may be an adequate tool to overcome the well-known age-bias of electronic surveys. As for the average age for each modality, in the 2021 onsite surveys the average age for shore anglers was 47, for boat anglers it was 49 and for spearfishers it was 40. In the 2021 online surveys, the average ages were 46, 52 and 46 for shore angling, boat angling, and spearfishing respectively. On the other hand, in 2022 the results were similar. In the onsite surveys, the average age for shore anglers was 45, for boat anglers it was 52 and for spearfishers it was 36. In the 2022 online surveys, the average ages were 48, 54 and 47 for shore angling, boat angling, and spearfishing respectively (Figure 65). These results are consistent with previous findings in Catalonia and Spain, which found boat anglers to be, on average, the oldest participants, and spearfishers the youngest (Gordoa et al., 2019; ICATMAR, 2020a; ICATMAR,2022).

The years of experience practicing the activity was another question in the onsite and online surveys. As expected, boat anglers were the most experienced fishers in 2021 with 24 and 27 years of experience in the onsite and online surveys respectively. In 2022, boat anglers were also the most experienced fishers with an average of 24 years of experience in the onsite and 30 in the online surveys. For shore fishers, the average years of experience in 2021 was around 20 in both the onsite and online surveys and in the two years compared. On the other hand, spearfishing responses showed the largest experience gap between the onsite and online responses, with 18 and 23 years of experience in 2021 respectively (Figure 66). For 2022, the gap between the two surveys responses was even larger, with an average of 17 years of experience in the onsite and 26 in the online surveys (Figure 66b).

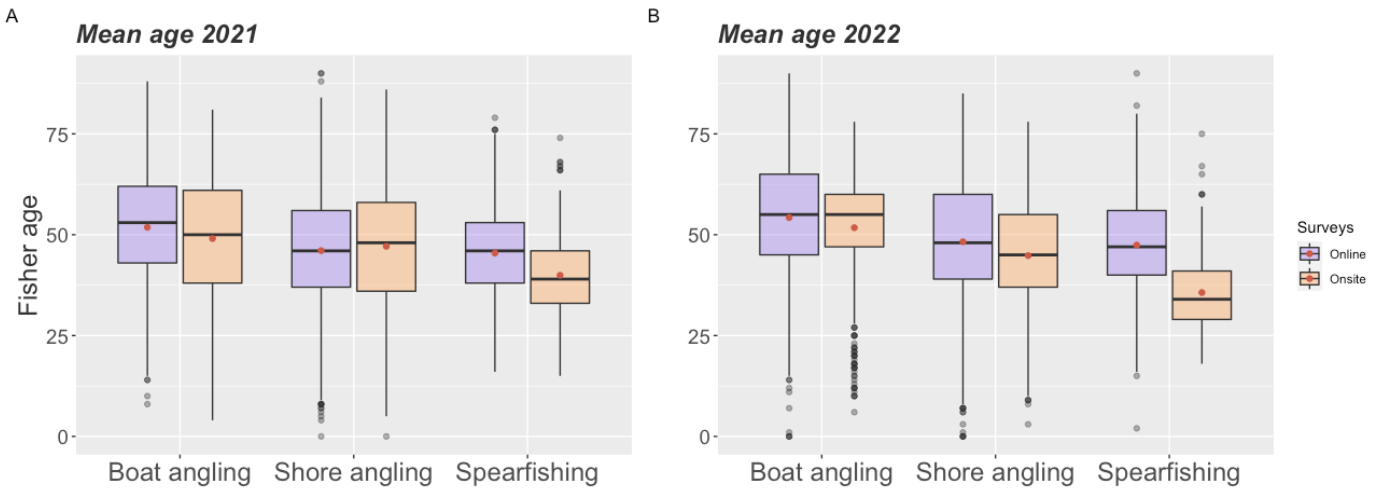

Figure 65: Boxplots recreational fisher's age in 2021(A) and fisher's age in 2022(B) obtain from the onsite surveys (in orange) and the online surveys (in purple) during 2021. Box limits represent interquartile rages, and vertical lines represent the 95% confidence interval (CI). Black dots represent extreme values outside the 95% CI. Average values are expressed by the horizontal black line, and median values are indicated with a red dot.

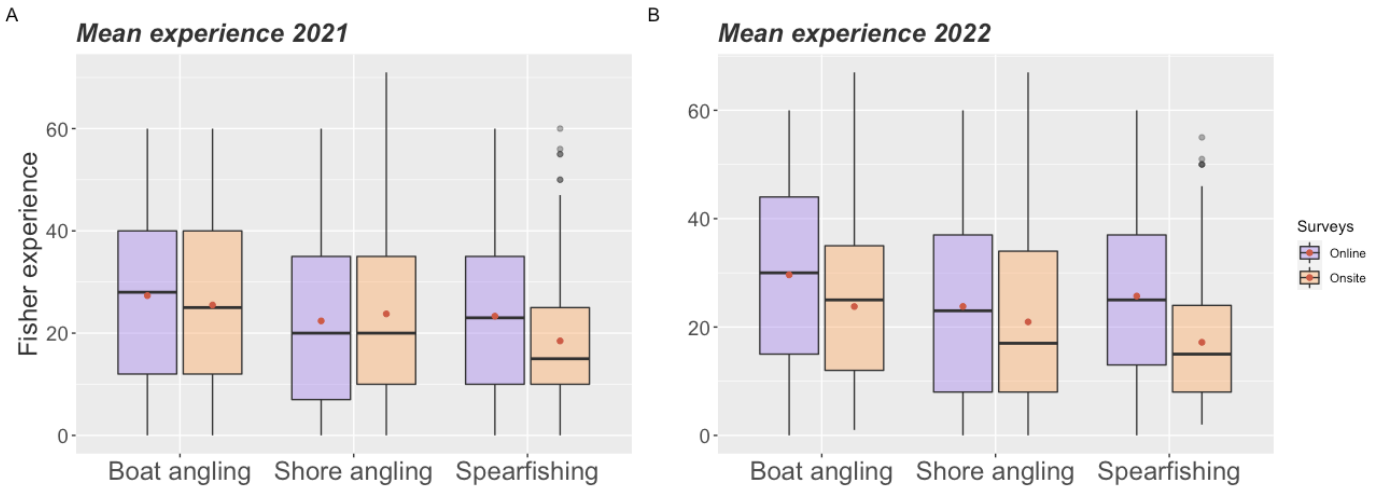

Figure 66: Boxplots recreational fisher's experience in 2021 (A) and fisher's experience in 2022 (B) obtain from the onsite surveys (in orange) and the online surveys (in purple) during 2022. Box limits represent interquartile rages, and vertical lines represent the 95% confidence interval (CI). Black dots represent extreme values outside the 95% CI. Average values are expressed by the horizontal black line, and median values are indicated with a red dot.

Both results from 2021 and 2022 showed in the onsite surveys that most fishers practice the activity in company (85% and 82% respectively). This underlines the predominantly social nature of MRF in Catalonia. There were important differences in the sociability response between both types of survey for which we could not provide an explanation. In addition, a considerable proportion of users are known to actively share their catches on one or many social media outlets, and almost 40% share their catches via private messaging services (Vitale, G. et al. 2021), which further highlights the highly social nature of MRF for many of its participants.

8

Economic impact of marine recreational fishing

The direct and indirect economic impacts of MRF were estimated using daily and annual expenditure data from the online surveys. Information on daily expenditure was requested for the latest fishing trip, as the respondent declared good recall of the trip. The daily information requested included costs on transport, bait and fishing materials, fuel for the boat (if a boat was used), port services (if applicable) and meals. The daily expenditure declared by each fisher on their latest fishing trip was extrapolated to their annual fishing days to obtain an individual annual estimate of their total expendable expenditure for their annual trips. Expenditure relating to periods longer than the immediate fishing trip were asked on an annual basis. These include more permanent fishing materials, boat maintenance and port services (when applicable), fishing holidays, fishing licences, insurances, club memberships, boat rentals and other annual expenses. Expenses related to the purchase of boats have been omitted from this study, and only those related to the use of the boat have been attributed to the practice of MRF. Information on charter fishing has been omitted from the analysis due to the very low number of respondents who reported spending money on this activity (N = 22 in 2021 and N = 29 in 2022).

In terms of per-capita expenditures, shore-based fishing activities incurred considerably lower expenses, with shore angling having the lowest economic impact, followed by shore-initiated spearfishing. Boat angling and boat-initiated spearfishing entailed considerably higher expenses, most of which were related to the maintenance and use of the vessel.

In 2021, the results of the daily expenditures per fisher estimated an average expenditure of 28.90€ per fishing trip for shore anglers, 58.05€ for boat anglers, 22.67€ for shore-initiated spearfishers, and 41.17€ for boat-initiated spearfishers. Daily expenditures were annualized using fisher effort data, and added to the expenses that were measured on an annual basis. Average annual expenditures amounted to 811.8€ for shore angling, 3 503.9€ for boat angling, 1 030.4€ for spearfishers primarily starting the activity from land, and 3 180.7€ for spearfishers mainly starting the activity from a boat (Table 15).

In 2022, the results of the daily expenses per angler estimated an average expenditure of 29.16€ per fishing trip for shore anglers, 62.73€ for boat anglers, 26.31€ for spearfishers initiating the activity from land, and 50.03€ for spearfishers who initiate the activity from a boat. Daily expenses were annualized using fisher effort data, and were added to the expenses that were measured on an annual basis. Average annual expenditures amounted to 887.6€ for shore fishing, 4 436.4€ for boat fishing, 1 297.9€ for spearfishing primarily initiating the activity from land, and 3 466.9€ for spearfishers initiating the activity mainly from a boat (Table 17).

The average annual expenditure per fisher was multiplied by the total estimated number of recreational fishers for each of the fishing modalities to obtain an estimate of the total activity expenditure. During 2021, the total of 31 100 shore anglers was estimated to have generated an economic impact of 25.2M€ (Table 16). The main expenditure in shore angling was on fishing gear (4.6M€ on consumables and 8M€ on permanent gear), followed by fishing holidays (3.5M€) and other daily expenses such as transportation and meals (8.1M€). An increase was recorded in 2022, when it was estimated that 31 693 shore anglers have generated a total expenditure of 28.1M€ (Table 18). The main expenditure in shore angling was on fishing gear (4.6M€ on consumables and 8.8M€ on permanent gear), followed by fishing holidays (4.1M€) and other daily expenses such as transportation and meals (8,7M€).

In 2021, the total of 10 367 boat anglers was estimated to have generated an economic impact of 33.8M€ (Table 16). The main expenditures of boat angling were on maintenance and port services, totalling 12.1M€ (7.1M€ on port services and 4M€ on boat maintenance). The other expenditures of this modality were very diversified: 6.9M€ were spent on fishing holidays, 4.3M€ on boat fuel and 6.5M€ on fishing gear (2.5M€ on consumables and 4M€ on permanent gear). In regards to 2022, it was estimated that 11 722 boat anglers generated an economic impact of 48M€ (Table 18). The main expenditure for boat angling was on maintenance and port services, totalling 17.3M€ (10.4M€ on port services and 6.9M€ on boat maintenance). The other expenses of this modality were very diversified: 3.1M€ were spent on fishing holidays, 5.2M€ on boat fuel and 8.8M€ on fishing gear (5.6M€ on consumables and 3.2M€ on permanent gear).

Table 15. Estimates of average expenses per recreational fisher (RF) and total activity expenses in Catalonia for each modality during 2021. Daily expenses include Consumable gear, boat fuel (if applicable) and other daily expenses. Consumable gear includes expenses typically done multiple times a year and in preparation for upcoming fishing trips, including bait, hooks, weights, floats and lines. Other daily expenses aggregates expenses related to meals and travel (public transportation tickets, fuel, tolls and parking). Long-term expenses are estimated on a yearly basis, and include permanent gear, boat services and boat maintenance (if applicable), fishing holidays, fishing licences, insurances, club memberships, boat rentals and other annual expenses. Permanent gear includes expenses in fishing materials bought on a larger time-scale, and includes fishing rods, reels, spears, wetsuits, clothes for fishing and other fishing accessories. Fishing holidays include all expenses for trips made with the main purpose of practicing MRF. Other annual expenses relate to all long-term expenses not included in previous sections, such as fishing apps, maps, guides, subscriptions and others.

	Shore angling		Boat angling		Spearfishing			
					Initiating from land		Initiating from boat	
	Annual expenditure per RF	Total activity expenditure	Annual expenditure per RF	Total activity expenditure	Annual expenditure per RF	Total activity expenditure	Annual expenditure per RF	Total activity expenditure
Consumable gear	148,26 €	4.610.886 €	240,10 €	2.489.117 €	114,68 €	224.564 €	91,70 €	73.343 €
Boat fuel			423,44 €	4.389.802 €		NA	398,23 €	318.512 €
Other daily expenses	262,03 €	8.149.133 €	633,96 €	6.572.263 €	429,41 €	840.862 €	498,07 €	398.366 €
Permanent gear	258,25 €	8.031.575 €	393,86 €	4.083.147 €	162,90 €	318.988 €	301,53 €	241.170 €
Port services			828,19 €	7.126.252 €		NA	766,92 €	613.398 €
Boat maintenance			573,02 €	4.930.614 €		NA	555,33 €	444.164 €
Holidays	111,58 €	3.470.138 €	143,12 €	1.483.725 €	232,30 €	454.885 €	306,88 €	245.449 €
License	18,75 €	583.125 €	19,29 €	199.979 €	32,60 €	63.837 €	31,24 €	24.986 €
Insurances	2,99 €	92.989 €	140,45 €	1.456.045 €	17,90 €	35.051 €	104,10 €	83.261 €
Clubs memberships	3,25 €	101.075 €	40,33 €	418.101 €	21,40 €	41.905 €	46,88 €	37.496 €
Other anual expenses	6,73 €	209.303 €	32,32 €	335.061 €	19,20 €	37.597 €	60,06 €	48.037 €
Boat rentals			35,83 €	371.450 €	NA	NA	14,71 €	11.765 €
TOTAL ANNUAL	**811,84 €**	**25.248.224 €**	**3.504 €**	**33.855.556 €**	**1.030 €**	**2.017.689 €**	**3.181 €**	**2.539.948 €**

In the case of spearfishing, the results were separated between spearfishers who start fishing from the shore and those who start fishing from a boat. In total, there were 2 758 recreational spearfishers during 2021, of which 1 958 were those starting primarily from shore and 800 primarily from a boat (see table 15). It was estimated that shore-initiated spearfishers generated a total expenditure of 2M€ (Table 16). Their main expenditure was on other daily expenses (0.8M€), followed by fishing holidays (0.5M€), and fishing gear 0.5M€ (0.2M€ on consumables and 0.3M€ on permanent gear; see Table X). In the case of boat-initiated spearfishers it was estimated that they generated a total expenditure of 2.5M€. In this case, there were additional costs associated with fuel (0.4M€), boat maintenance and port services (1.1M€ altogether). In 2022, there were 2 985 recreational spearfishers, of which 2 298 were those starting primarily from shore and 687 primarily from a boat. It was estimated that shore-initiated spearfishers generated an economic impact of 3M€ (Table 17). Their main expenditure was on other daily expenses (1.4M€), followed by fishing gear 0.7M€ (0.3M€ on consumables and 0.4M€ on permanent gear) and fishing holidays (0.6M€; see Table X). On the other hand, it was estimated that boat-initiated spearfishers generated a total economic impact of 2.4M€ (Table 18). In this case, there were additional costs associated with fuel (0,3M€) boat maintenance and port services (0.8M€ altogether).

Expenditures were classified as direct economic impacts of the activity on materials that can be obtained from fishing gear shops, or as indirect impacts, which refer to expenditures incurred outside the recreational fishing service provision sector, such as fishing holidays, meals, transport, boat renting, maintenance and port services. During 2021, the total expenditure of shore angling was estimated to be €12.6 million for direct impacts, and €25.2 million including all costs associated with the activity (Table 16). Direct expenditure on boat-based fishing gear and materials was estimated at €6.5M, while the total direct plus indirect costs of the activity amounted to €33.9M. Shore and boat-initiated spearfishing had direct economic impacts on fishing gear of €0.54M and €0.31M respectively. The total direct and indirect impacts of the activity were estimated at €2M and €2.5M respectively, totalling €4.5M for spearfishing activity as a whole.

Table 16. Estimate of total direct annual expenditure on fishing materials and gear, and total annual expenditure related to the fishing activity including indirect expenses for each MRF modality during 2021.

2021	Fishing gear	Total activity
Shore angling	12 642 461€	25 248 224€
Boat angling	6 572 263€	33 855 556€
Spearfishing from land	543 552€	2 017 689€
Spearfishing from boat	314 513€	2 539 948€
Total	**20 072 789€**	**63 289 968€**

Table 17. Estimates of average expenses per recreational fisher (RF) and total activity expenses in Catalonia for each modality during 2022. Daily expenses include Consumable gear, boat fuel (if applicable) and other daily expenses. Consumable gear includes expenses typically done multiple times a year and in preparation for upcoming fishing trips, including bait, hooks, weights, floats and lines. Other daily expenses aggregates expenses related to meals and travel (public transportation tickets, fuel, tolls and parking). Long-term expenses are estimated on a yearly basis, and include permanent gear, boat services and boat maintenance (if applicable), fishing holidays, fishing licences, insurances, club memberships, boat rentals and other annual expenses. Permanent gear includes expenses in fishing materials bought on a larger time-scale, and includes fishing rods, reels, spears, wetsuits, clothes for fishing and other fishing accessories. Fishing holidays include all expenses for trips made with the main purpose of practicing MRF. Other annual expenses relate to all long-term expenses not included in previous sections, such as fishing apps, maps, guides, subscriptions and others.

	Shore angling		Boat angling		Spearfishing			
					Initiating from land		Initiating from boat	
	Annual expenditure per RF	Total activity expenditure	Annual expenditure per RF	Total activity expenditure	Annual expenditure per RF	Total activity expenditure	Annual expenditure per RF	Total activity expenditure
Consumable gear	145,67 €	4.616.719 €	474,70 €	5.564.433 €	132,29 €	304.062 €	162,89 €	111.832 €
Boat fuel			445,10 €	5.217.462 €			558,33 €	383.321 €
Other daily expenses	306,15 €	9.702.812 €	899,28 €	10.541.360 €	604,33 €	1.389.022 €	679,60 €	466.579 €
Permanent gear	276,95 €	8.777.376 €	276,94 €	3.246.291 €	198,50 €	456.242 €	226,79 €	155.703 €
Port services			1.073,15 €	10.440.955 €			709,49 €	487.100 €
Boat maintenance			707,70 €	6.885.397 €			502,86 €	345.239 €
Holidays	127,99 €	4.056.387 €	264,07 €	3.095.429 €	268,40 €	616.904 €	407,71 €	279.913 €
License	17,21 €	545.437 €	19,74 €	231.392 €	29,80 €	68.494 €	32,67 €	22.430 €
Insurances	4,09 €	129.624 €	162,11 €	1.900.253 €	20,50 €	47.118 €	107,37 €	73.715 €
Clubs memberships	3,85 €	122.018 €	34,65 €	406.167 €	21,30 €	48.957 €	41,09 €	28.210 €
Other anual expenses	5,69 €	180.333 €	31,52 €	369.477 €	22,80 €	52.405 €	25,33 €	17.390 €
Boat rentals			47,46 €	94.575 €	NA	NA	12,84 €	8.815 €
TOTAL ANNUAL	**887,60 €**	**28.130.707 €**	**4.436 €**	**47.993.194 €**	**1.298 €**	**2.983.204 €**	**3.467 €**	**2.380.248 €**

In 2022, it was estimated that total expenditures of shore angling were 13.4M€ for direct impacts, and 28.1M€ including all costs associated with the activity (Table 18). Direct expenditure on boat-based fishing gear and materials were estimated at 8.8M€, while the total direct plus indirect expenses of the activity amounted to 48M€. Shore and boat-initiated spearfishing had direct economic impacts on fishing gear of 0.76M€ and 0.27M€ respectively. The total direct and indirect impacts were estimated at 3M€ and 2.4M€ respectively, amounting to a total 5.4M€ for the spearfishing activity as a whole.

Table 18. Estimate of total direct annual expenditure on fishing materials and gear, and total annual expenditure related to the fishing activity including indirect expenses for each MRF modality during 2022.

2022	Fishing gear	Total activity
Shore angling	13 394 096€	28 130 707€
Boat angling	8 810 724€	47 993 194€
Spearfishing from land	760 304€	2 983 204€
Spearfishing from boat	267 535€	2 380 248€
Total	**23 232 659 €**	**81 487 353 €**

The areas with the highest economic impact in 2021 for all three modalities of MRF were the Costa Brava Sud, Costes del Garraf and Costa Daurada (Figure 67). Shore angling and boat angling, were also highly impactful on the Delta de l'Ebre zone, while shore angling produced most of its expenditure in the Maresme zone.

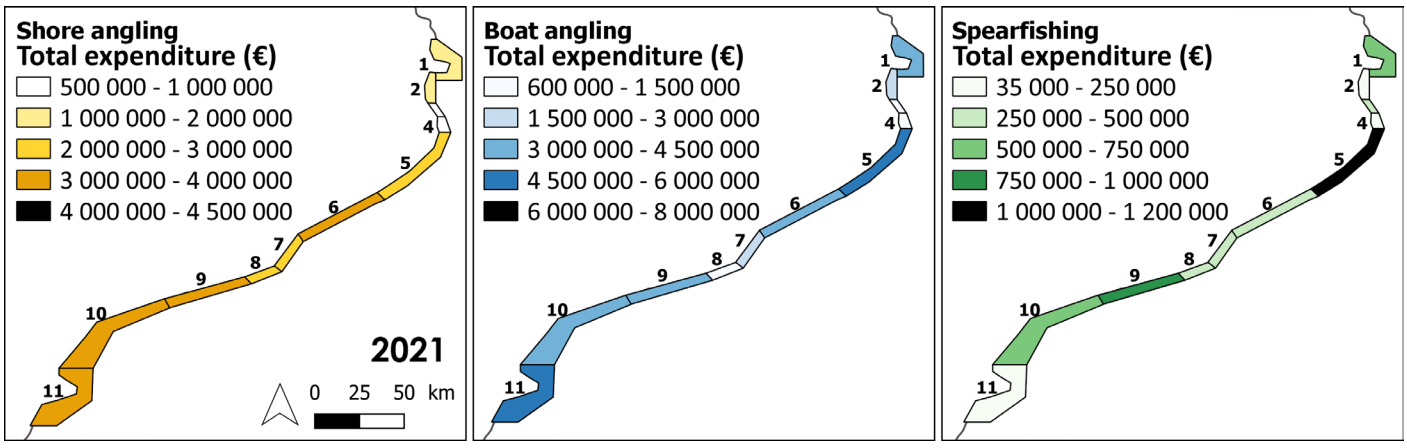

Figure 67: Estimate of t0tal annual expenditure related to fishing activity for each MRF modality per zone in 2021.

In 2022, where there was a higher total expenditure compared with 2021, the areas with the highest economic impact for all three modalities of MRF were the Costa Brava Sud and Costa Daurada (Figure 68). Shore angling was also highly impactful on the Maresme zone, while boat angling produced most of it is expenditure in the Delta de l'Ebre zone.

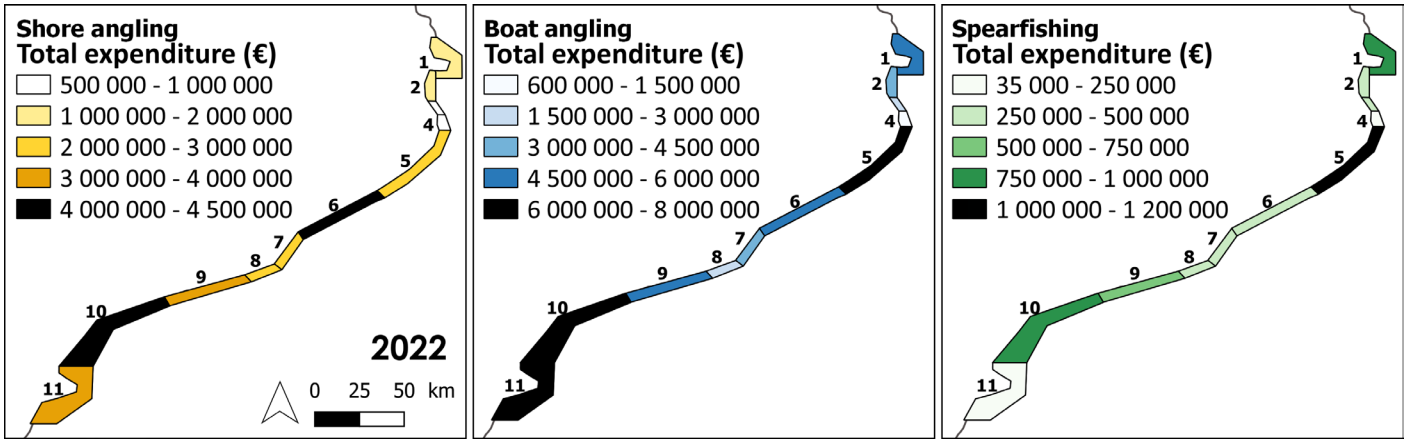

Figure 68: Estimate of total annual expenditure related to fishing activity for each MRF modality per zone in 2022.

9
Conclusions

Recreational fishing was practised by an estimated 44 224 recreational fishers in 2021 in Catalonia while, in 2022, it was practised by an estimated 46 400 recreational fishers.

MRF is predominantly practised by middle-aged men with at least a decade of experience, although the different fishing modalities are represented by slightly different age-groups, with boat anglers being the oldest, and spearfishers the youngest. In the online surveys conducted in 2022, the percentage of female marine recreational fishers has increased.

In both years, the most practised fishing modality was shore angling (52%), followed by boat angling (37% in 2021 and 36% in 2022) and, to a lesser extent, spearfishing (11% in 2021 and 12% in 2022).

MRF is highly seasonal activity strongly influenced by good weather and high temperatures, with the main bulk of the activity taking place during the months of May to September.

The main taxonomic groups targeted by MRF are species of the *Sparidae* family, but the main catches for each modality varied significantly. Shore angling caches include mainly the gilthead seabream (*Sparus aurata*), different seabream species of the genera *Diplodus*, and European bass (*Dicentrarchus labrax*).Boat angling mostly extracts biomass of common dentex, *Dentex dentex*, pelagic species such as *Euthynnus alletteratus*, *Seriola dumerili* and *Scomber scombrus*, common cuttlefish (*Sepia officinalis*) and European squid (*Loligo vulgaris*). Spearfishing catches mainly include the dusky grouper *Epinephelus marginatus*, along with a variety of sparids and the common octopus (*Octopus vulgaris*).

The total annual extraction of marine resources in 2021 was estimated in 510 T for MRF as a whole, while in 2022, the total annual extraction increased to 779 T. This total catch would represent 3% of the commercial fishing catch in Catalonia (ICATMAR, 2020b).

It is necessary to caution that nature of this study is heavily dependent on voluntary surveys and interpretation of the results presented here should not ignore the existence of unavoidable method-driven biases that have been outlined throughout the text. Although the combined methodology of online and onsite surveys allowed overcoming some of the shortcomings of each survey method, it is likely that inherent self-selection, perception and memory biases affect indicators that require fishers to recall their past experiences.

The overview of MRF activity represented by this study can be made more reliable year after year to become a major contribution to inform multidisciplinary decision-making aimed at good management of the sector. Thus, the continuity of a series producing accurate annual data will be essential to maintain a sufficient body of knowledge to allow MRF to be included in fisheries assessments in the near future. This is considered a cornerstone in the progress toward informed decision-making for the sustainability of Catalan fisheries.

10
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11
Annexes

11.1. ANNEX I

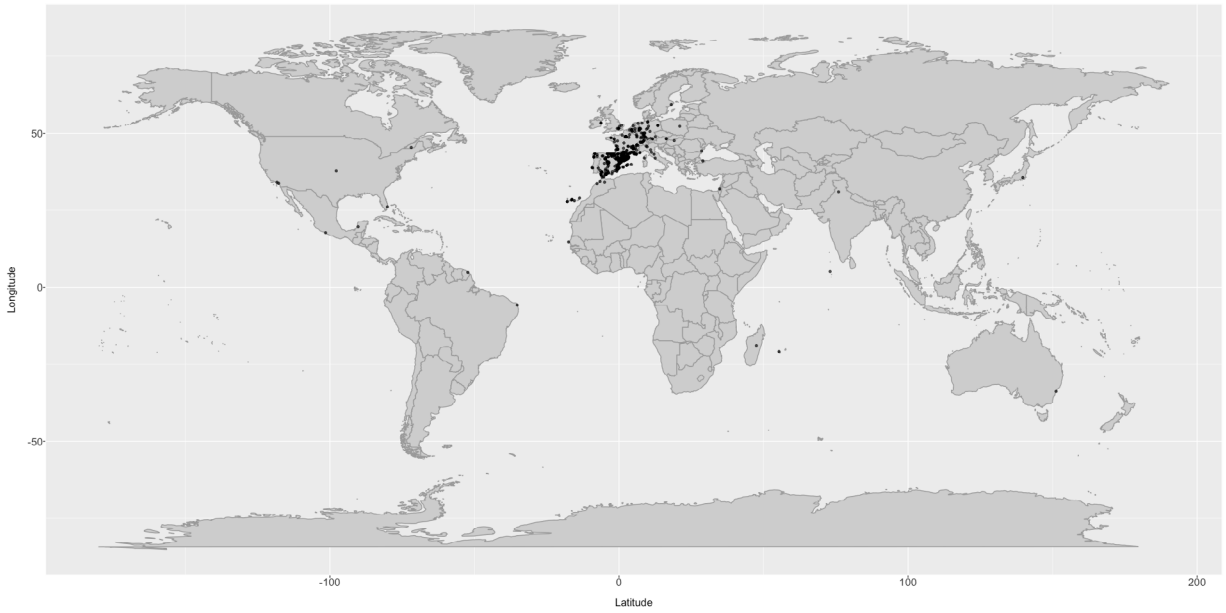

Figure 69: Global map of all locations of responses from online surveys conducted by marine recreational fishers during 2021.

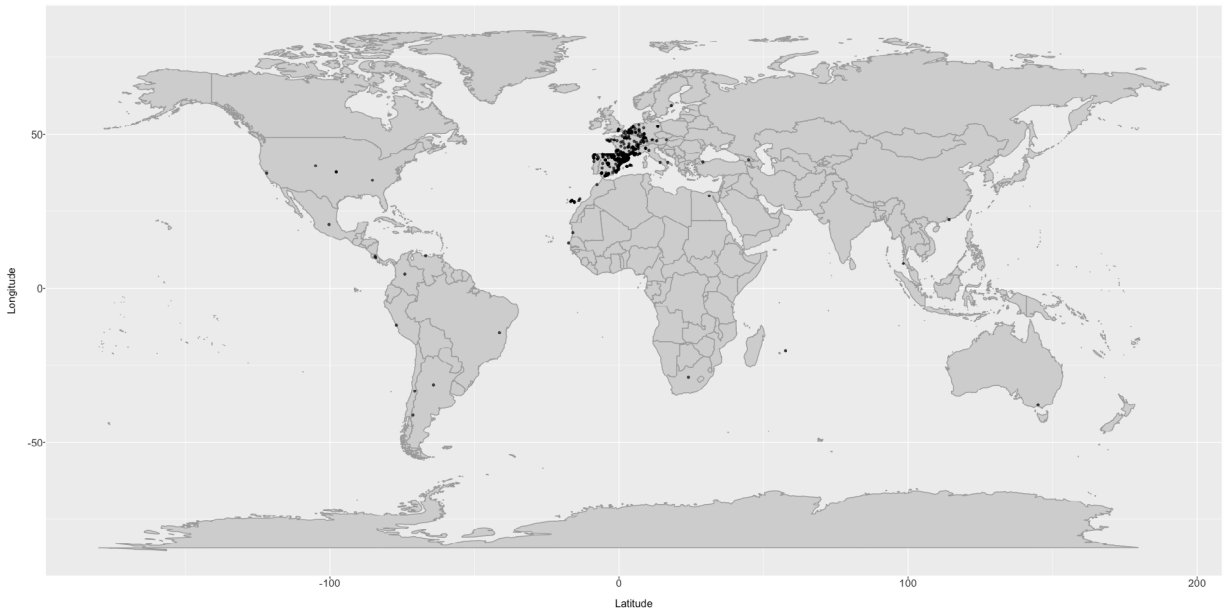

Figure 70: Global map of all locations of responses from online surveys conducted by marine recreational fishers during 2022.

11.2. ANNEX II: Fishing effort

Table 19. Distribution of shore angling effort in 2021

Zones	Winter	Spring	Summer	Autumn
Cap de Creus	5%	5%	5%	5%
Golf de Roses	6%	6%	6%	5%
Costa del Montgrí	2%	3%	5%	4%
Baix Ter	2%	3%	3%	2%
Costa Brava Sud	8%	10%	9%	10%
Maresme	14%	15%	12%	15%
Barcelonès	11%	8%	9%	8%
Delta del Llobregat	9%	8%	7%	7%
Costes del Garraf	14%	15%	15%	14%
Costa Daurada	15%	15%	17%	15%
Delta de l'Ebre	15%	13%	14%	15%

Table 20. Total estimate number shore angling trips per kilometre per season in 2021

Zones	Km coastline	Winter	Spring	Summer	Autumn	Total annual
Cap de Creus	97.46	41	77	95	64	277
Golf de Roses	22.78	206	377	582	281	1 446
Costa del Montgrí	14.2	131	270	667	330	1 398
Baix Ter	9.75	157	488	669	289	1 602
Costa Brava Sud	79.1	84	196	234	158	672
Maresme	60.22	186	367	402	301	1 257
Barcelonès	18.4	465	666	984	569	2 683
Delta del Llobregat	19.5	373	591	691	433	2 087
Costes del Garraf	52.7	211	441	571	329	1 552
Costa Daurada	83.06	150	282	413	224	1 068
Delta de l'Ebre	113.8	106	167	250	162	685

Table 21. Distribution of shore angling effort in 2022

Zones	Winter	Spring	Summer	Autumn
Cap de Creus	6%	6%	6%	5%
Golf de Roses	6%	6%	6%	7%
Costa del Montgrí	2%	3%	2%	2%
Baix Ter	1%	3%	2%	2%
Costa Brava Sud	11%	8%	8%	8%
Maresme	15%	13%	14%	15%
Barcelonès	10%	9%	8%	9%
Delta del Llobregat	6%	8%	8%	8%
Costes del Garraf	16%	16%	15%	14%
Costa Daurada	13%	13%	16%	16%
Delta de l'Ebre	13%	14%	16%	15%

Table 22. Total estimate number shore angling trips per kilometre per season in 2022

Zones	Km coastline	Winter	Spring	Summer	Autumn	Total annual
Cap de Creus	97.46	86	89	122	70	367
Golf de Roses	22.78	320	360	508	444	1 632
Costa del Montgrí	14.2	181	357	257	247	1 042
Baix Ter	9.75	176	495	374	297	1 342
Costa Brava Sud	79.1	182	149	215	154	701
Maresme	60.22	331	329	485	367	1 512
Barcelonès	18.4	687	682	926	763	3 059
Delta del Llobregat	19.5	396	631	858	604	2 489
Costes del Garraf	52.7	399	435	589	392	1 814
Costa Daurada	83.06	199	238	403	291	1 131
Delta de l'Ebre	113.8	149	182	291	203	826

Table 23. Distribution of boat angling effort in 2021

Zones	Winter	Spring	Summer	Autumn
Cap de Creus	12%	10%	11%	12%
Golf de Roses	6%	7%	10%	11%
Costa del Montgrí	5%	4%	4%	2%
Baix Ter	2%	2%	1%	3%
Costa Brava Sud	14%	13%	13%	13%
Maresme	10%	13%	8%	8%
Barcelonès	8%	9%	9%	7%
Delta del Llobregat	4%	3%	2%	3%
Costes del Garraf	11%	11%	12%	10%
Costa Daurada	15%	11%	12%	16%
Delta de l'Ebre	13%	16%	18%	15%

Table 24. Total estimate number boat angling trips per kilometre per season in 2021

Zones	Km coastline	Winter	Spring	Summer	Autumn	Total annual
Cap de Creus	97.46	52	65	110	74	301
Golf de Roses	22.78	109	192	398	297	997
Costa del Montgrí	14.2	139	184	244	99	666
Baix Ter	9.75	81	112	109	168	470
Costa Brava Sud	79.1	76	105	159	106	446
Maresme	60.22	70	141	133	85	429
Barcelonès	18.4	193	320	464	241	1 218
Delta del Llobregat	19.5	81	101	96	108	385
Costes del Garraf	52.7	85	137	223	120	564
Costa Daurada	83.06	74	84	132	118	408
Delta de l'Ebre	113.8	48	86	148	82	365

Table 25. Distribution of boat angling effort in 2022

Zones	Winter	Spring	Summer	Autumn
Cap de Creus	14%	8%	12%	14%
Golf de Roses	9%	5%	6%	9%
Costa del Montgrí	4%	3%	3%	4%
Baix Ter	3%	2%	3%	2%
Costa Brava Sud	12%	22%	14%	14%
Maresme	10%	12%	11%	7%
Barcelonès	7%	6%	6%	6%
Delta del Llobregat	2%	1%	4%	5%
Costes del Garraf	11%	11%	11%	7%
Costa Daurada	14%	14%	11%	16%
Delta de l'Ebre	14%	16%	19%	16%

Table 26. Total estimate number boat angling trips per kilometre per season in 2022

Zones	Km coastline	Winter	Spring	Summer	Autumn	Total annual
Cap de Creus	97.46	89	68	137	122	415
Golf de Roses	22.78	245	168	283	356	1 052
Costa del Montgrí	14.2	196	171	242	220	830
Baix Ter	9.75	172	142	309	192	815
Costa Brava Sud	79.1	95	215	190	158	659
Maresme	60.22	111	156	200	104	571
Barcelonès	18.4	258	245	374	288	1 166
Delta del Llobregat	19.5	72	53	243	208	576
Costes del Garraf	52.7	138	165	229	118	649
Costa Daurada	83.06	107	134	140	165	546
Delta de l'Ebre	113.8	76	107	185	123	491

Table 27. Distribution of spearfishing effort in 2021

Zones	Winter	Spring	Summer	Autumn
Cap de Creus	11%	9%	13%	10%
Golf de Roses	3%	4%	5%	2%
Costa del Montgrí	5%	4%	7%	9%
Baix Ter	1%	1%	0%	1%
Costa Brava Sud	18%	28%	22%	25%
Maresme	9%	8%	4%	3%
Barcelonès	11%	4%	6%	7%
Delta del Llobregat	5%	3%	7%	7%
Costes del Garraf	14%	21%	14%	20%
Costa Daurada	20%	17%	15%	12%
Delta de l'Ebre	2%	2%	5%	2%

Table 28. Total estimate number spearfishing trips per kilometre per season in 2021

Zones	Km coastline	Winter	Spring	Summer	Autumn	Total annual
Cap de Creus	97.46	10	15	37	13	74
Golf de Roses	22.78	9	27	59	11	106
Costa del Montgrí	14.2	29	43	147	78	297
Baix Ter	9.75	11	12	0	17	41
Costa Brava Sud	79.1	19	57	79	40	195
Maresme	60.22	12	20	20	7	59
Barcelonès	18.4	51	33	97	51	232
Delta del Llobregat	19.5	21	25	107	48	201
Costes del Garraf	52.7	23	62	76	47	208
Costa Daurada	83.06	20	32	52	18	123
Delta de l'Ebre	113.8	1	3	13	2	20

Table 29. Distribution of spearfishing effort in 2022

Zones	Winter	Spring	Summer	Autumn
Cap de Creus	13%	9%	14%	19%
Golf de Roses	4%	4%	5%	5%
Costa del Montgrí	9%	4%	7%	9%
Baix Ter	1%	3%	3%	1%
Costa Brava Sud	20%	23%	22%	20%
Maresme	8%	5%	7%	8%
Barcelonès	9%	5%	4%	5%
Delta del Llobregat	9%	12%	7%	4%
Costes del Garraf	11%	14%	12%	12%
Costa Daurada	12%	14%	15%	15%
Delta de l'Ebre	3%	6%	3%	2%

Table 30. Total estimate number spearfishing trips per kilometre per season in 2022

Zones	Km coastline	Winter	Spring	Summer	Autumn	Total annual
Cap de Creus	97.46	19	20	45	31	115
Golf de Roses	22.78	25	37	69	36	168
Costa del Montgrí	14.2	90	60	160	95	405
Baix Ter	9.75	15	58	90	15	178
Costa Brava Sud	79.1	36	64	86	41	227
Maresme	60.22	19	19	38	20	95
Barcelonès	18.4	69	62	67	45	242
Delta del Llobregat	19.5	65	131	108	35	339
Costes del Garraf	52.7	30	59	73	37	199
Costa Daurada	83.06	20	38	57	28	143
Delta de l'Ebre	113.8	4	12	9	3	28

11.3. ANNEX III: Fishing yield by fishing modality

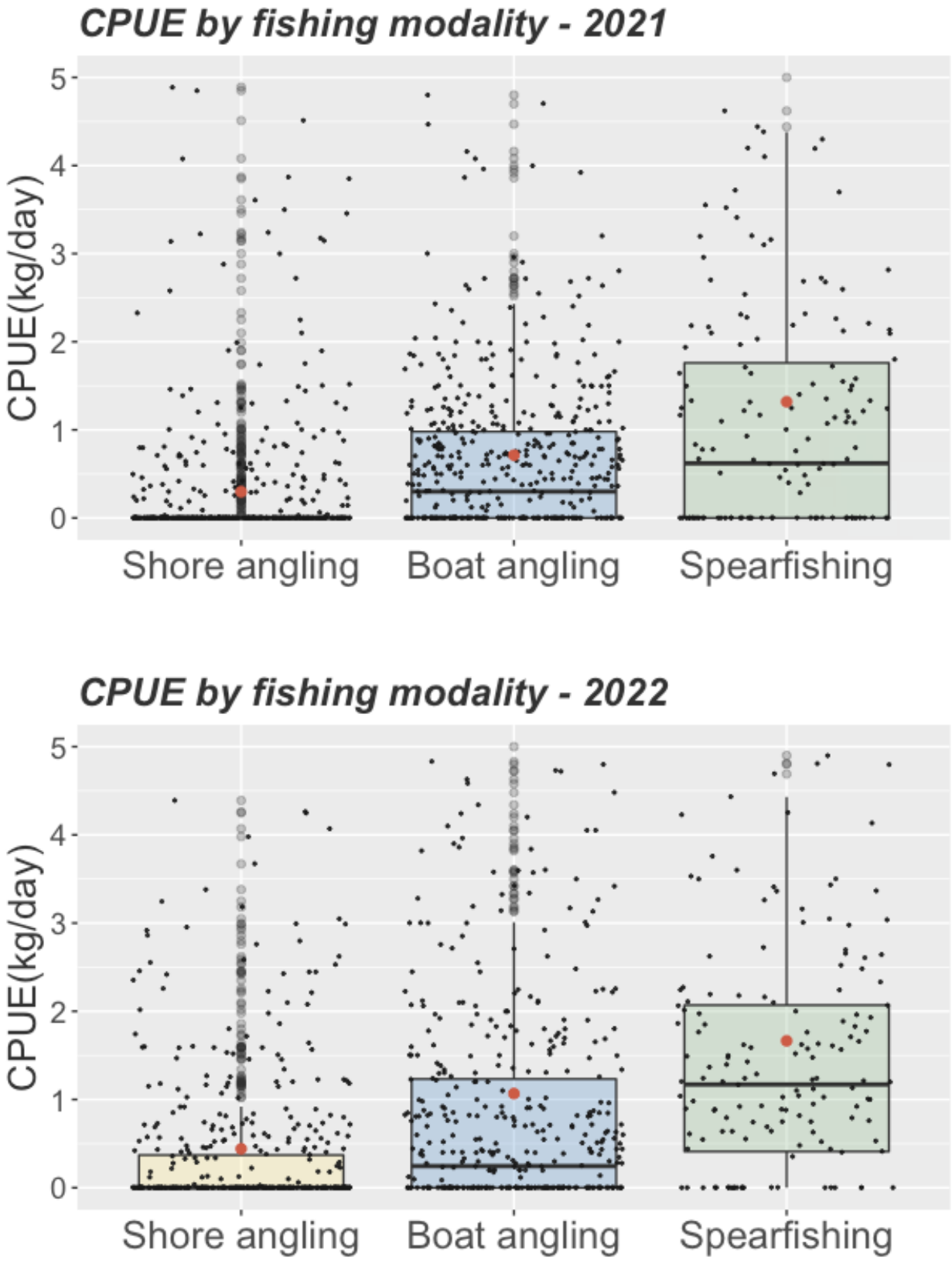

Figure 71: CPUE by each MRF modality in 2021 (top) and 2022 (bottom). The red dot indicates the mean, the horizontal black line represents the median value. The boxes represent the interquartile ranges (25 – 75%) and the vertical line represents the 90% spread of the data

11.4. ANNEX IV: Seasonal catch composition 2021

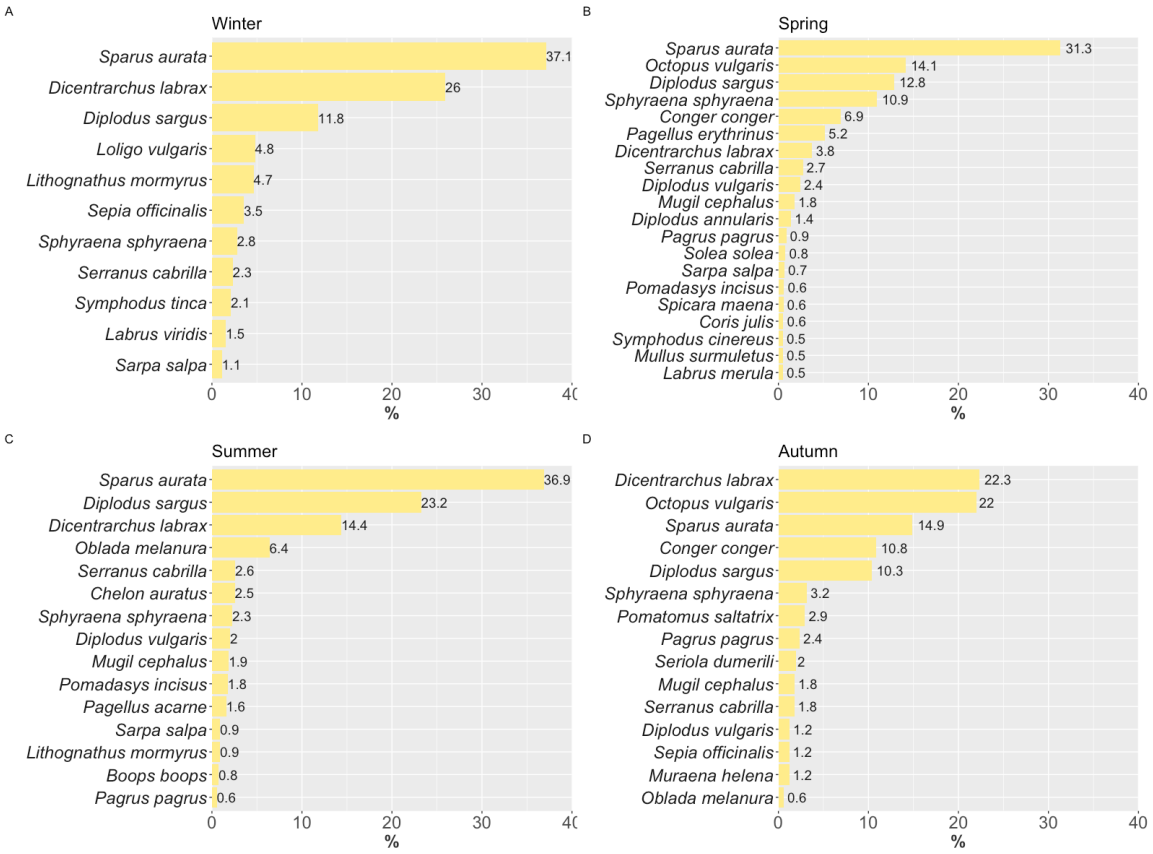

Figure 72: Catch composition (in weight %) by shore angling in winter (A), in spring (B), in summer (C) and in autumn (D). Only species with a relative weight of more than 1% of the total catch are shown.

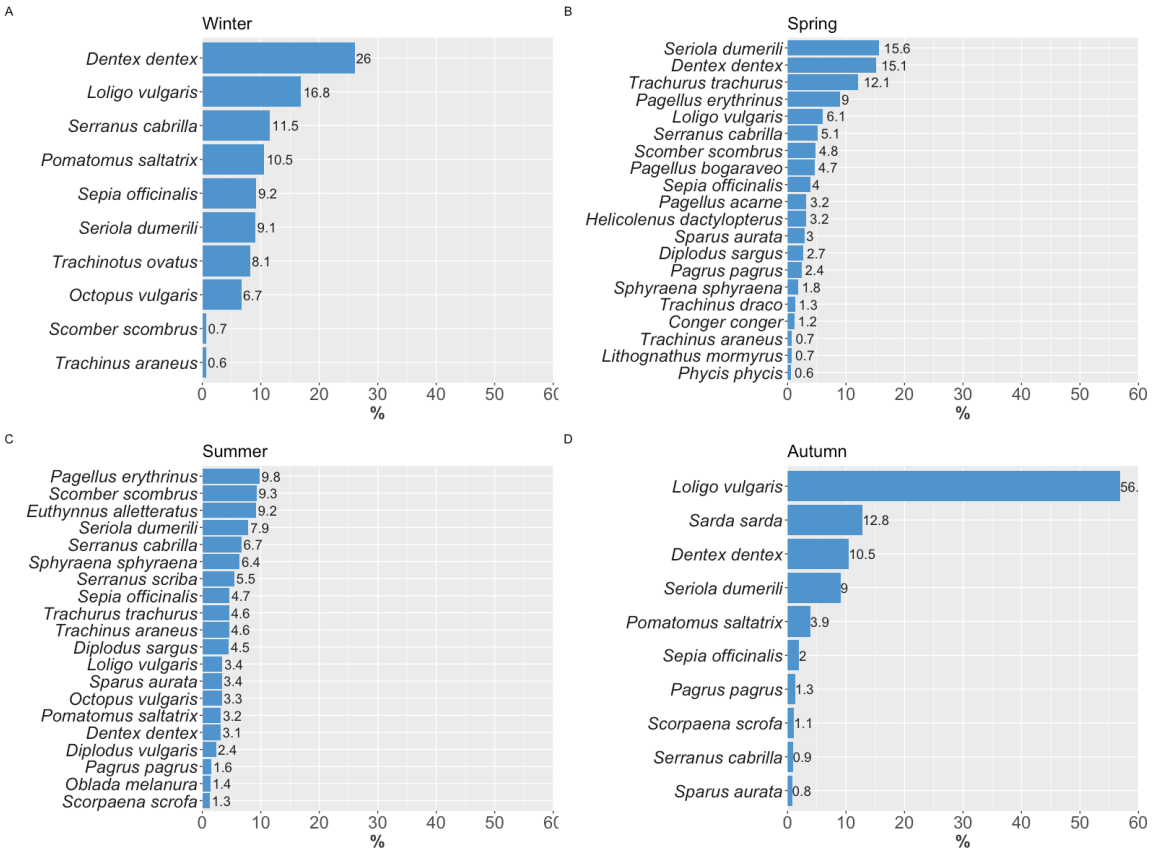

Figure 73: Catch composition (in weight %) by boat angling in winter (A), in spring (B), in summer (C) and in autumn (D). Only species with a relative weight of more than 1% of the total catch are shown.

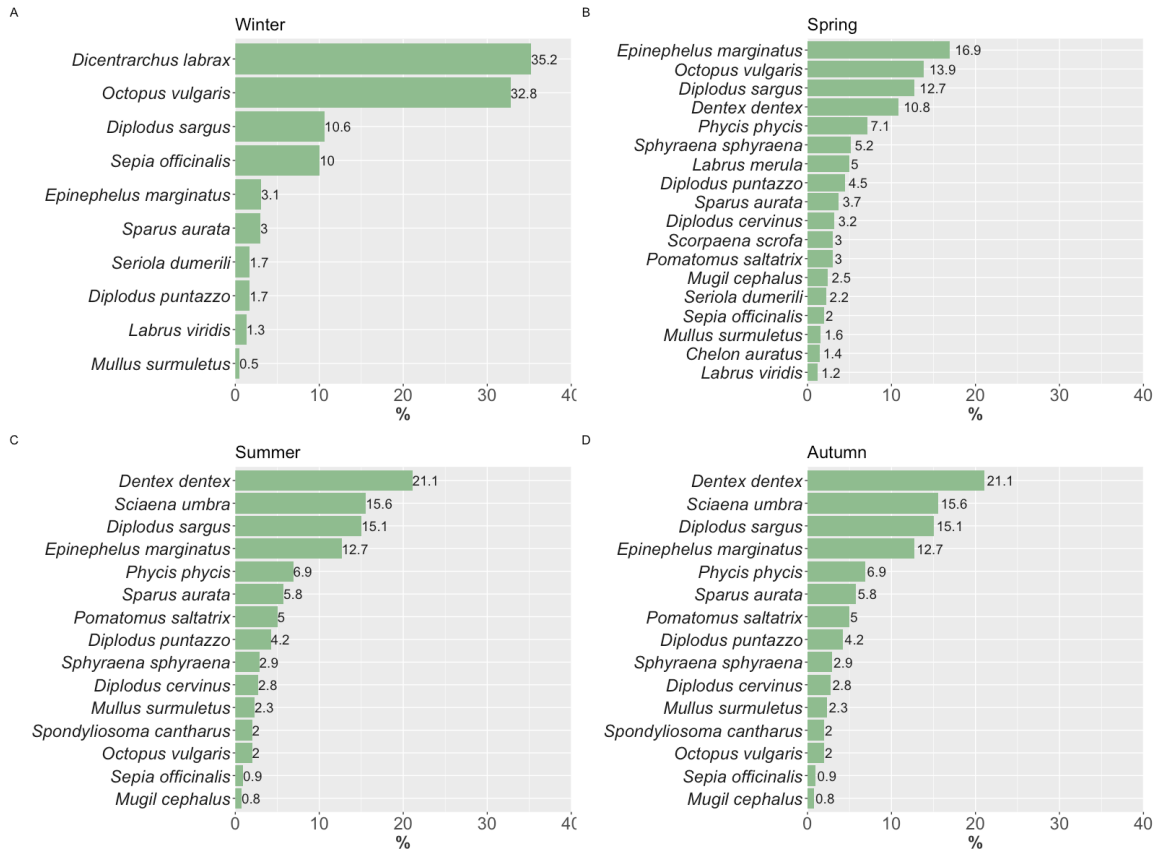

Figure 74: Catch composition (in weight %) by spearfishing in winter (A), in spring (B), in summer (C) and in autumn (D). Only species with a relative weight of more than 1% of the total catch are shown

11.5. ANNEX V: Seasonal catch composition 2022

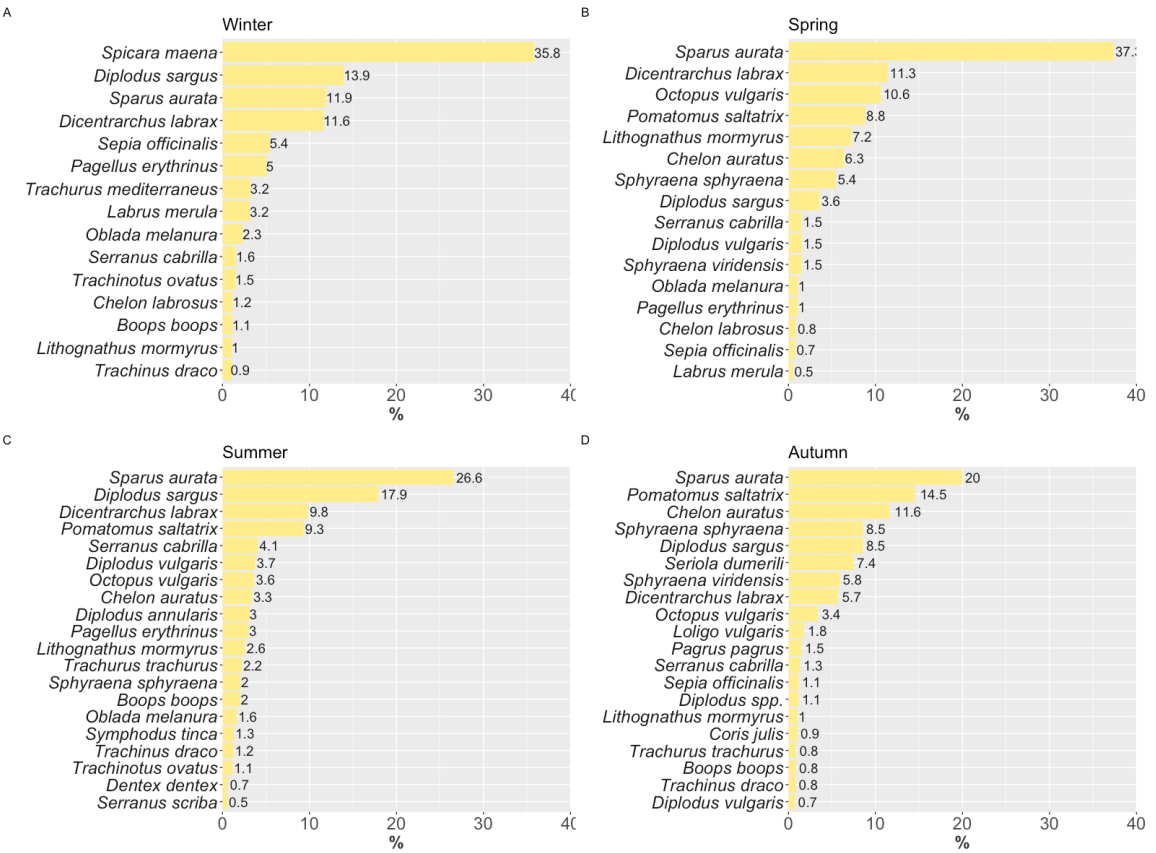

Figure 75: Catch composition (in weight %) by shore angling in winter (A), in spring (B), in summer (C) and in autumn (D). Only species with a relative weight of more than 1% of the total catch are shown.

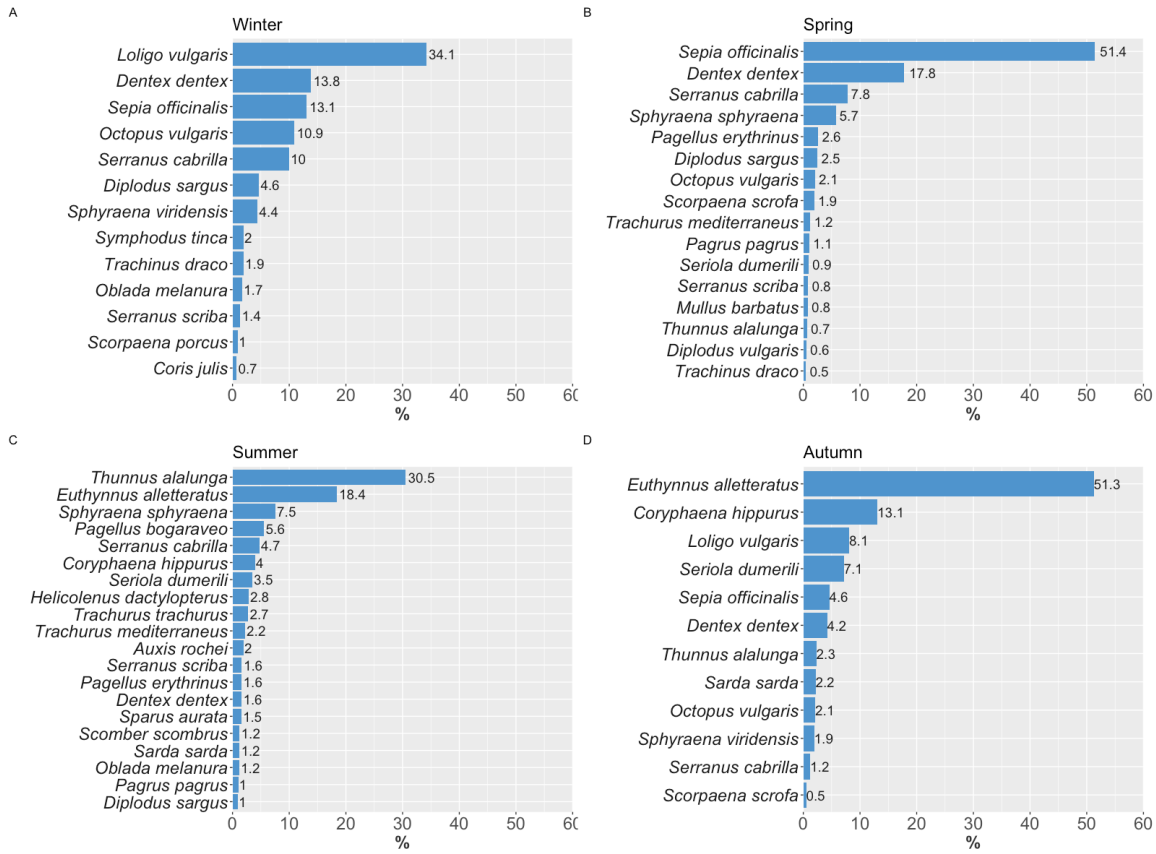

Figure 76: Catch composition (in weight %) by boat angling in winter (A), in spring (B), in summer (C) and in autumn (D). Only species with a relative weight of more than 1% of the total catch are shown.

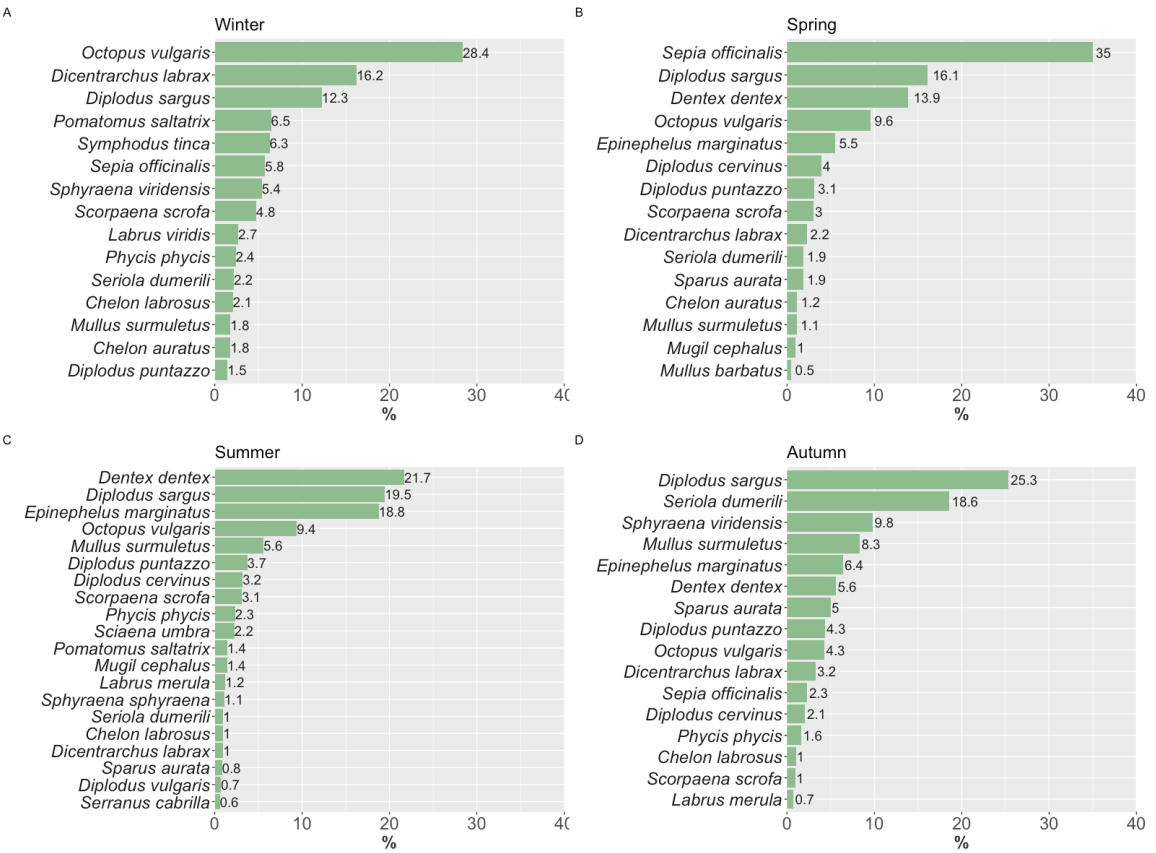

Figure 77: Catch composition (in weight %) by spearfishing in winter (A), in spring (B), in summer (C) and in autumn (D). Only species with a relative weight of more than 1% of the total catch are shown.

11.6. ANNEX VI: Distribution of the total activity expenditure

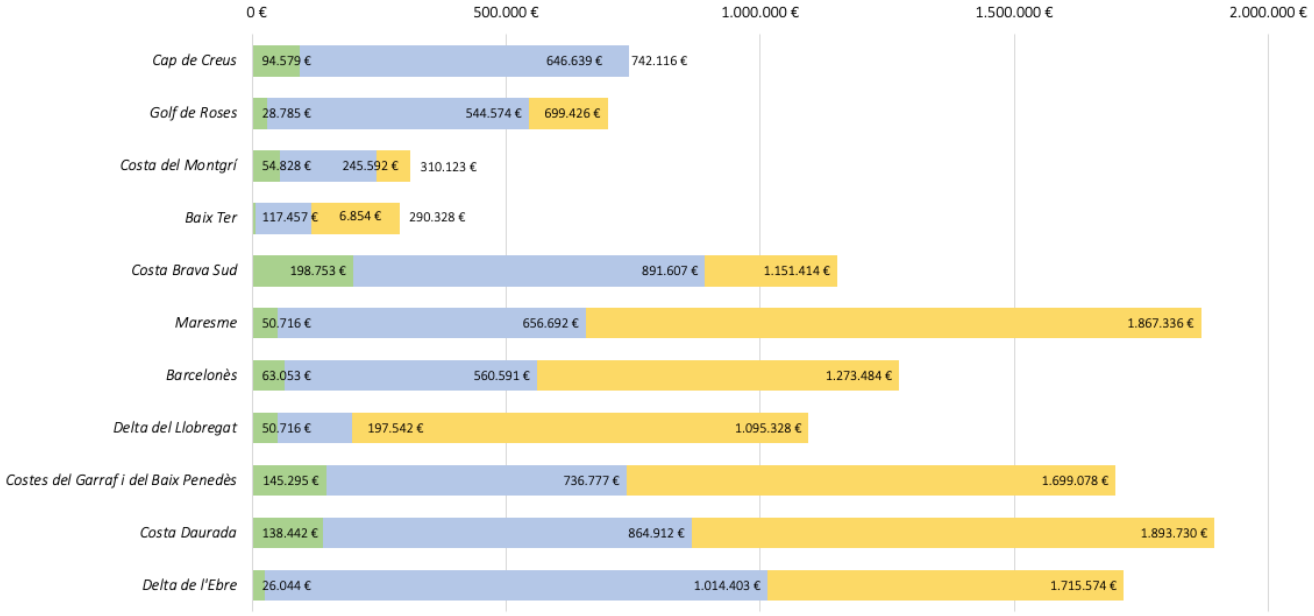

Figure 88: Estimate of total annual fishing gear related to fishing activity for each modality by zone during 2021.

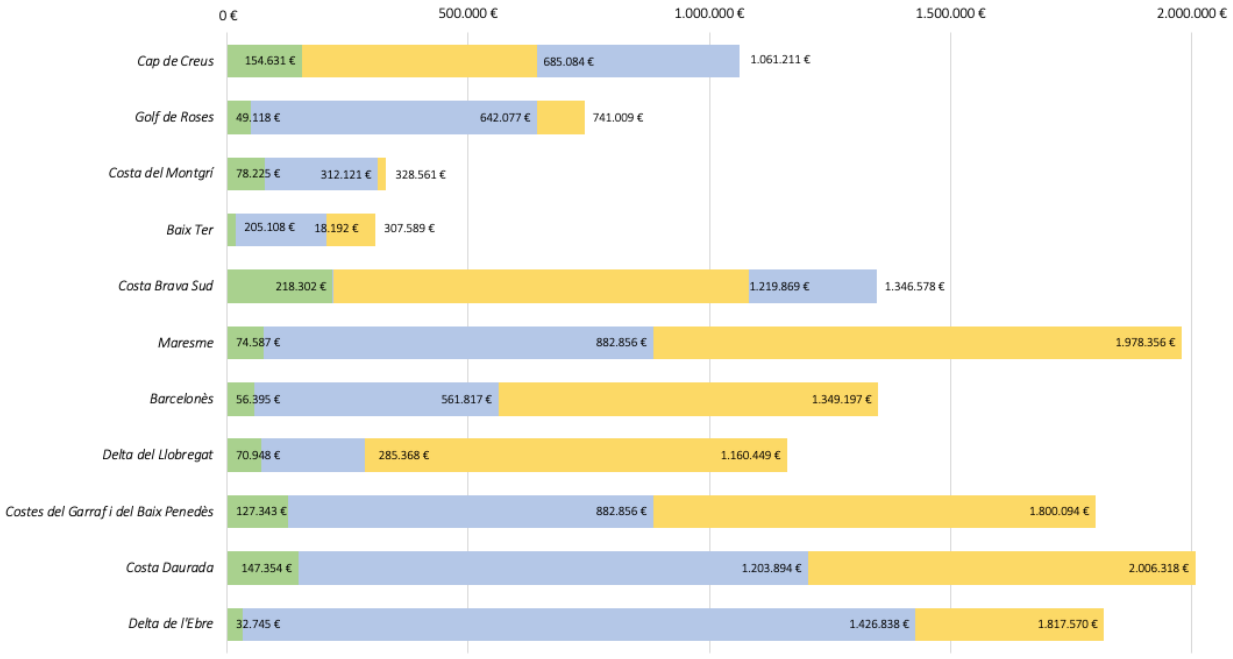

Figure 89: Estimate of total annual fishing gear related to fishing activity for each modality by zone during 2022.

11.7. ANNEX VII: A brief summary of the scientific days initiated by marine recreational fishers

The Catalan Association for Responsible Fishing (ACPR) was created in Catalonia in 1999. It is a non-profit organisation that acts in defence of the interests of surface recreational marine fishing users with the administration. This organisation is made up of members of APERS (Alliance of Spanish Sustainable Recreational Fishing), which includes representatives of national and international organisations in the sector. Thus, the ACPR carries out various tasks with the aim of promoting values and transmitting knowledge and interest in marine recreational fishing through collaboration with scientific, environmental education and training entities on issues related to recreational fishing resources.

In this context, the collection of data on recreational marine fishing by the ACPR is a clear example of the public's interest in participating in scientific processes and making significant contributions that contribute to the good state of the environment. In 2022, as part of the development of the Pilot Plan on Recreational Marine Fishing Science Days, ACPR developed a data collection methodology that includes three strategies:

- Data collection: recording the size and position of catches and effort (number of rods, number of fishers and fishing time).
- Tagging: data collection and tagging of fish with conventional tags, and recording of tags implanted.
- Organisation of participatory workshops: these can be on either of the above two topics and follow the same methodology.

With the help of a collaboration protocol that establishes the necessary guidelines, this data can be a very useful input in the framework of the recreational marine fishing monitoring programme that ICATMAR has been carrying out since 2019. ICATMAR is interested in incorporating citizen science procedures as part of its knowledge transfer strategy. The interest in this initiative is common to both entities. On the one hand, ACPR is in a key position to pool its knowledge and its relationship with the recreational marine fishing community in order to disseminate throughout the sector the need to manage the ecosystems they use. On the other hand, ICATMAR is keen to incorporate citizen science procedures as part of its knowledge transfer strategy.

11.8. ANNEX VIII: A brief summary of fishing charters data collection

A fishing charter is a guided fishing trip run by a professional charter Captain. The charter typically provides everything the customer needs for a fishing trip, including the boat, captain, bait, and equipment. In Catalonia there are about 30 registered charters (with collective licences). In 2020, when the continuous sampling started, the presence of charters was taken into account and a voluntary form was created and sent to fishers when they registered as a collective licence charter so they could report catches. However, this initiative was not successful. Three years later, in 2022, meetings were arranged with charterers (charter owners) to explain them the importance of data collection in marine recreational fishing and the future management measures established by the EU regarding recreational fishing. They were asked to collaborate by adapting the catch report form and adding a survey for charter customers. These forms and surveys were sent out in September 2022 and responses from 3 charters were received: a total of 14 trips during the months of October and November 2022 and January and February 2023 were reported. Currently, an effort to improve the form and survey is being conducted in order to achieve a higher quantity and better quality of answers.

11.9. ANNEX IX: List of species

Table 31. Alphabetic list of all species observed with a scientific noun and common name.

Scientific name	Catalan common name	Spanish common name	English common name
Anthias anthias	Forcadella	Tres colas	Swallowtail seaperch
Boops boops	Boga	Boga	Bogue
Bothus podas	Tacó	Podas	Wide-eyed flounder
Conger conger	Congre	Congrio	European conger
Coris julis	Donzella, juliola	Doncella, julia	Rainbow wrasse
Coryphaena hippurus	Llampuga	Llampuga	Common dolphinfish
Dentex dentex	Déntol	Dentón	Common dentex
Dicentrarchus labrax	Llobarro	Lubina	European seabass
Diplodus sargus	Sard, sarg	Sargo	White seabream
Diplodus cervinus	Sard imperial, rom	Sargo imperial	Zebra seabream
Diplodus vulgaris	Variada, vidriada	Sargo común, mo-jarra	Common two-banded seabream
Diplodus puntazzo	Morruda	Sargo picudo	Sharpsnout seabream
Diplodus annularis	Esparrall	Raspallón	Annular seabream
Epinephelus marginatus	Mero, nero, anfós	Mero	Dusky grouper
Euthynnus alletteratus	Bacoreta	Bacoreta	Atlantic black skipjack
Helicolenus dactylopterus	Penegal, serrà imperial	Gallineta, pollo	Blackbelly rosefish
Labrus merula	Tord negre, tord massot	Merlo	Brown wrasse
Labrus viridis	Grívia, tord verd	Tordo verde	Green wrasse
Lichia amia	Palomida	Palometón	Leerfish
Lithognathus mormyrus	Marbre, mabre	Herrera, mabre	Sand steenbras
Loligo vulgaris	Calamar comú	Calamar común	European squid
Chelon labrosus	Llissa vera	Lisa	Thicklip grey mullet
Mugil cephalus	Llissa llobarrera	Mugil	Flathead grey mullet
Chelon auratus	Llissa galta-roja	Lisa dorada	Golden grey mullet
Mullus surmuletus	Moll de roca, roger	Salmonete de roca	Surmullet
Mullus barbatus	Moll de fang	Salmonete de fango	Red mullet
Muraena helena	Morena	Morena	Mediterranean moray
Oblada melanura	Oblada	Oblada	Saddled seabream
Octopus vulgaris	Pop roquer	Pulpo común	Common octopus
Pagellus acarne	Besuc blanc, calet	Aligote	Axillary seabream
Pagellus bogaraveo	Besuc de la piga	Besugo	Blackspot seabream
Pagellus erythrinus	Pagell	Breca, pagel	Common pandora
Pagrus pagrus	Pagre	Pargo, pagro	Red porgy, common seabream
Paracentrotus lividus	Garota	Erizo de mar	Stony sea urchin
Phycis phycis	Mòllera, bròtola	Brótola de roca	Forkbeard

Scientific name	Catalan common name	Spanish common name	English common name
Pomatomus saltatrix	Tallahams, lliri	Anjova	Bluefish
Sarda sarda	Bonítol	Bonito del Sur	Atlantic bonito
Sarpa salpa	Salpa	Salema	Salema
Sciaena umbra	Corball de roca	Corvallo	Brown meagre
Scomber scombrus	Verat, cavalla	Caballa	Atlantic mackerel
Scomber colias	Bis	Estornino	Pacific chub mackerel
Scorpaena scrofa	Escórpora de cap roig, polla	Cabracho	Red scorpionfish
Scorpaena porcus	Escórpora, rufí	Rascacio	Black scorpionfish
Sepia officinalis	Sèpia, sípia	Sepia común	Common cuttlefish
Seriola dumerili	Círvia	Pez limón	Greater amberjack
Serranus cabrilla	Serrà	Cabrilla	Comber
Serranus scriba	Vaca serrana	Vaquita, cabrilla	Painted comber
Sparus aurata	Orada	Dorada	Gilthead seabream
Sphyraena sphyraena	Espet	Espetón	European barracuda
Sphyraena viridensis	Espet	Espetón boca amarilla	Yellowmouth barracuda
Spicara maena	Xucla	Chucla	Blotched picarel
Spondyliosoma cantharus	Càntera	Chopa	Black seabream
Symphodus tinca	Tord lloro, llavió	Tordo verde, bodión	East Atlantic peacock wrasse
Symphodus mediterraneus	Tord porcellana, canari, tord roquer	Vaqueta	Axillary wrasse
Symphodus roissali	Planxeta	Planchita	Five-spotted wrasse
Tetrapturus belone	Marlí de la Mediterrània	Marlín del Mediterráneo	Mediterranean spearfish
Thunnus thynnus	Tonyina	Atún	Atlantic bluefin tuna
Thunnus alalunga	Bacora	Atún blanco	Albacore
Trachinotus ovatus	Palometa	Palometa blanca	Pompano
Trachurus trachurus	Sorell	Jurel	Atlantic horse mackerel
Trachurus mediterraneus	Sorell blanc	Jurel mediterráneo	Mediterranean horse mackerel
Umbrina cirrosa	Corball de sorra	Verrugato	Shi drum
Xiphias gladius	Emperador, peix espasa	Emperador, pez espada	Swordfish
Xyrichtys novacula	Raor, llorito	Galán, lorito	Pearly razorfish
Zeus faber	Gall de Sant Pere	Pez de San Pedro	John Dory
Anthias anthias	Forcadella	Tres colas	Swallowtail seaperch
Boops boops	Boga	Boga	Bogue
Bothus podas	Tacó	Podas	Wide-eyed flounder
Conger conger	Congre	Congrio	European conger
Coris julis	Donzella, juliola	Doncella, julia	Rainbow wrasse

Scientific name	Catalan common name	Spanish common name	English common name
Coryphaena hippurus	Llampuga	Llampuga	Common dolphinfish
Dentex dentex	Déntol	Dentón	Common dentex
Dicentrarchus labrax	Llobarro	Lubina	European seabass

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